# 1988 NASA AUTHORIZATION

# HEARINGS

BEFORE THE

## SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

OF THE

## COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

FIRST SESSION

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FEBRUARY 5, 24, 25; MARCH 3, 5, 10, 11, 18, 19, 31;
APRIL 23; MAY 6, 1987

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[No. 35]

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**VOLUME II**

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Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE

76-600 WASHINGTON : 1987

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

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*Ranking Republican Member.
**Resigned February 19, 1987 (H. Res. 89).
***Elected March 30, 1987 (H. Res. 133).

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# 1988 NASA AUTHORIZATION

THURSDAY, FEBRUARY 5, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
*Washington, DC.*

The committee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Robert A. Roe (chairman of the committee) presiding.

Mr. ROE. Good morning, ladies and gentlemen.

Today we commence our examination of the fiscal year 1988 budget request for the National Aeronautics and Space Administration. I want to welcome the Honorable James C. Fletcher, Administrator of NASA, to today's proceedings.

Although our discussion will focus on the specific budget recommendations and also, I might add, on the specific budget omissions, it should be understood that the fundamental issue is that budgets become statements of policy when there is an absence of overriding stated policy.

I am not going to read the statement. I think we will put it into the record.

[The prepared opening statement of Mr. Roe follows:]

OPENING REMARKS BY HON. ROBERT A. ROE, CHAIRMAN, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Today we commence our examination of the Fiscal Year 1988 budget request for the National Aeronautics and Space Administration. I want to welcome The Honorable James C. Fletcher, Administrator of NASA, to today's proceedings.

Although our discussion will focus on the specific budget recommendations, and also I might add, on the specific budget omissions, it should be understood that the fundamental issue is that budgets become statements of policy when there is an absence of overriding stated policy. The purpose of any budget is to reflect overall policy objectives and carry programs incrementally toward these goals.

Annual budgets without enunciated policy goals are like armies without generals; they are fragments and pieces that move independently in many directions but frequently lose sight of where the forward direction exists.

This nation must have a national space policy. The National Commission on Space projected long term space goals for the next fifty years. However, those goals begin with the operation of a permanently manned space station. There is much time, territory, and technology between now and the Space Commission's recommended goals. We at this Committee do not intend to leave that gap empty.

We are now starting the second year of our recovery from the Challenger crash. NASA and the Rogers Commission conducted an investigation into the cause of the accident. This Committee's comprehensive Challenger investigation resulted in 68 recommendations that were forwarded to NASA. We anticipate NASA's report on addressing those recommendations on February 15, just 10 days from now. We all share the priority of returning the Orbiter to flight status and once again asserting American space leadership.

Our purpose in beginning the deliberations of NASA's 1988 budget request with a Full Committee hearing is to extract first a general overview of the budget. The

NASA budget request reflects an increase of approximately $1 billion or nearly 12%. This increase is independent of the one-time appropriation of $2.1 billion approved last Congress for a replacement Orbiter.

There are several specific issues to keep in mind as we examine this budget. Although our priority is to get the Shuttle Flying, we know this is not the sole solution to our space transportation problems. We must map an overall plan for optimum use of the Shuttle while also working out the implementation of a mixed fleet policy. In addition, we will consider whether there is need for a new heavy-lift vehicle.

The Space Station received a large budget increase to support development activity planned to begin in FY 1988. It is important that this Committee derives distinct understanding of the goals for the Space Station program, the development costs, the operating costs, and the roles of foreign partners.

Together, this Committee and NASA must find mechanisms to control both development and operating costs. To control development costs, we might explore the possibility of authorizing the whole program now, laying out year-by-year authorization levels at the start. NASA's task would then be to build a station within those funding levels. For control of operating costs, I would emphasize the importance for NASA to maintain a strong management role here along with some system of incentives to lower operating costs over the life of the Station.

Two budget omissions raise serious concerns. There is no money in the budget for the continuation of the Advanced Communications Technology Satellite (ACTS) program and there is no funding for NASA to buy Expendable Launch Vehicles (ELVs).

Dr. Fletcher, I would hope that together we could find a mechanism to keep the ACTS program of course. On the ELV issue, reality dictates that ELVs are needed not only for dealing with the existing backlog of payloads but also to increase the capability of our Space Transportation System to assure us uninterrupted access to space. I would like you to share with us your intentions concerning ELVs.

Lastly, the generation of new knowledge is one of NASA's fundamental missions and it is through our space science programs that much of this is accomplished. We are seriously concerned that the nation's space science program is in jeopardy. The lack of flight opportunities for space science projects foretells a grim future for young scientists. This nation stands to lose a whole generation of space scientists as the prospect of "no flights" during their career-time drives them into other fields.

In addition, indications from the science community suggest that NASA is "strongly encouraging" that all science be done on the Space Station or on associated platforms. Surely the Station is not an optimal environment for all science uses. A young space scientist looking at this future can see only bleakness.

To speak of the space science future is not to ignore its current debility. At this moment, for want of space—accessing capability, the Galileo Mission to Jupiter, the Ulysses Solar-Polar Mission, and the Hubble Space Telescope lie grounded, despite the fact that they are poised and prepared to obtain invaluable information about our universe. The inability to launch the Hubble Telescope is particularly distressing because it costs us $6 million a month to protect it on the ground. It is vital that NASA take the responsibility for correcting this disastrous course.

Dr. Fletcher, we have a large and formidable agenda to discuss and resolve. We as a Committee look forward to working with you in the coming months.

Mr. ROE. What we are more interested in hearing from you is what it amounts to. It has been a year since we have had a chance to get together formally from the accident that took place almost a year ago today, and what we are hoping to do is look into where NASA is going, where your program is, what we are achieving as it relates to the commission's recommendations and this committee's recommendations, and what the future of NASA is going to be.

All of us have been reading different reports in the press on prognostics, and people are talking about what they think the issues are. I hope today we will have the opportunity to settle that and decide exactly the direction we want to go.

Without further ado, I refer to my good friend, Congressman Lujan, our Ranking Republican.

Mr. LUJAN. Thank you.

This has been a difficult year for NASA. It was more than the loss of an orbiter—an asset they could ill afford to lose. For many

it was also the loss of seven friends. But perhaps even more painful for the agency, it was the end of the uncritical admiration of the public, the press and many in Congress.

This has been a difficult time for Congress as well. We have also taken considerable criticism for our role in this tragedy—for helping to create the environment that pushed NASA into taking the chances they did.

However, this has also been a time for reflection. What should NASA's primary role in the civilian space program be? We now have the opportunity to redefine that role, and I think we should.

The shuttle had been the focal point of NASA's space program and, in fact, had become for many an end in itself. The loss of the Challenger not only interrupted the shuttle program, it interrupted the nation's entire space program. The whole premise that NASA's primary mission and goal should be the efficient operation of a space bus is now being questioned.

The Challenger accident was a terrible tragedy, but the real tragedy will be if we simply fix the joint and return to business as usual. And yet I sense that many, both within NASA and outside of NASA as well, believe that once the shuttle is flying again everything will be okay, that everything will go back to the way it was before. If that happens, we will have lost an opportunity.

We in Congress have an obligation to help set the future course for the space program. Whether we retain the lead in space or continue to focus on an operational transportation system is largely up to us.

Last year this committee wrote legislation which would establish a Space Council which could provide some guidance and focus for a civil space program. That legislation was vetoed by the administration because it was viewed as congressional meddling into Executive Branch business. I sympathize with that view. I am sure my colleagues would not have welcomed administration attempts to organize this committee. However, it is clear that something needs to be done to get our space program on track. I, for one, would welcome an administration initiative to establish their own framework for setting the nation's goals for the space program and the implementation plans for carrying out that program. Something is needed, and in the absence of some positive action on the part of the administration, I feel confident that this committee will once again attempt to fill that void.

There is a great deal of confusion about where we are going with regard to space transportation. Are we going to simply add a few ELVs and continue to rely on NASA to be the primary, if not the sole, provider of launch services (the only difference being the use of a mixed fleet instead of relying solely on the shuttle)? Or will NASA begin focusing more on R&D?

I hope we will be able to identify the stumbling blocks to a viable commercial launch services industry. We must do what is necessary to put the industry into a healthy competitive position and then get the government out of it. NASA should be providing the R&D for the next generation space transportation needs, not operating the current system.

I am pleased to see the administration support of the aerospace plane program. It is a program that deserves our support, and I

simply want to urge NASA to continue to resist the efforts of some to focus on any single application for this technology. We certainly don't want to limit its potential at this early stage in its development.

Dr. Fletcher, I also share the concerns of many in the scientific community that large operations budgets adversely impact the space sciences program. We have an obligation to see that the space station doesn't become a huge resource sink. Already we are hearing that the costs are rising well beyond the initial estimates. In these days of budget cutting, this is naturally causing some concern. However, we can't afford to overlook what could become an even greater concern in the future. That is the caring and feeding costs of the station after it is completed.

NASA owes it to the members of this committee to accurately represent what it is we are being asked to fund. If we are buying a research facility, we need to know what capability we are buying, and we need to be given some accurate and credible cost figures so we can evaluate the merits of the various options. In turn, Congress owes it to NASA to not demand more for less.

Mr. Chairman, we all face a formidable challenge this year. I look forward to hearing how Dr. Fletcher plans to deal with some of these issues.

Thank you very much.

Mr. ROE. I thank the gentleman from New Mexico.

Do you want to introduce your colleagues for the record, and then will you proceed please?

**STATEMENT OF DR. JAMES C. FLETCHER, ADMINISTRATOR, THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DALE MYERS, DEPUTY ADMINISTRATOR, NASA; C. THOMAS NEWMAN, COMPTROLLER, NASA; BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR, SPACE SCIENCE AND APPLICATIONS, NASA; AND ADM. RICHARD H. TRULY, OFFICE OF SPACE FLIGHT, NASA**

Dr. FLETCHER. Yes, Mr. Chairman.

We have at the table, Dale Myers, my deputy, who came aboard last September; and we also have Tommy Newman, my old comptroller. We also have our management team on the first row, most of whom either are new or have new titles. I will just read off, if you will raise your hands as we go by, Phil Culbertson, Associate Administrator of Policy and Planning. He is not here. Dick Truly, Associate Administrator for Space Flight; Andy Stofan, Associate Administrator for the Space Station; Burt Edelson, Associate Administrator for Space Applications; June Brown, Associate Administrator for Management; Bob Aller, Associate Administrator for Space Operations. It is a new title for Bob. Ray Colladay, Associate Administrator for Aeronautics and Technology; John O'Brien, Chief Counsel; and Ike Gillam, Associate Administrator for Commercial Programs; and George Rodney, Associate Administrator for SRM, "M" stands for maintainability—it is a slightly different title than we had last year. And that is our team. There is one or two extra here to support us when we need it.

With your permission, I would like to submit my statement, which has been handed out to you, for the record and just sort of pick the highlights.

Mr. ROE. Without objection, so ordered. The statement will appear in the record.

Dr. FLETCHER. I am pleased to be back before you to present our fiscal year 1988 budget request, but before I get into the details, I would like to talk briefly about the progress that we have made since I last appeared before you, and as I already did, introduce the new management team.

Six months ago, when I accepted the Rogers Commission report on the Challenger accident, I pledged to take whatever actions necessary to make NASA a better organized, better managed, more competent, safer agency, thereby restoring the excellence that has been its hallmark for nearly three decades.

Today I am pleased to report that NASA is well on the road toward realizing those goals. We are not there yet, but we are on our way. A year after the Challenger accident, NASA has turned the corner in its recovery efforts. Difficult though this past year has been, it also has been a year of rebuilding and a year of strengthened resolve to return the nation to the forefront of space activities, safely and reliably.

We have recently announced a comprehensive NASA management reorganization based on recommendations from the Phillips Task Force. We are prepared in a safe and orderly way for the resumption of shuttle flights in February 1988 and for initiation of the developmental phase of the Space Station during fiscal year 1987. We are continuing our science and applications and other programs so vital to the expansion of human knowledge. We are further strengthening the technology upon which our leadership in space and aeronautics depends.

President Reagan's fiscal year 1988 budget request of $9.481 billion provides for a strong space program conceived in an environment of exceedingly tight Federal budget constraints. The NASA budget meets the highest priority needs identified during the budget formulation process and provides an effective base for developing a full program to assure United States leadership in space.

In fiscal year 1988, we will continue to give top priority to returning the shuttle to flight status. We will concentrate upon continued correction of the defects which have been found in the solid rocket booster which apparently caused the accident, the weaknesses and other elements of the system and on testing the modified systems to assure that they can be safely flown.

Also included is further implementation of the recommendations of the Rogers Commission to enhance our ability to sustain a safe and effective operation of the Shuttle. These activities are well underway in our schedule to permit safe flight on or about February 1988.

Production of an orbiter to replace the Challenger will be in progress using the full funding appropriated in fiscal year 1987, but as you know, we are not allowed to spend money on that program until August of this year. Space Transportation Operations funding supports a fiscal year 1988 launch schedule of four flights in fiscal year 1988, or in the first year, nine flights planned for fiscal year

1989. We have divided them into fiscal years in this statement so they are slightly different from what I mentioned last year. Four flights in fiscal 1988, nine in fiscal 1989, and ten in fiscal 1990. These are planning figures only and will be accomplished only if it is safe to do so.

NASA's Office of Space Flight, at my direction, has recently completed an analysis of the role of expendable launch vehicles as a complementary launch capability to the STS to assure future U.S. access to space. The findings of the "mixed fleet study" are that expendable launch vehicles could provide a viable and necessary augmentation in the overall launch capabilities of the U.S. Government. However, no final policy determination has been made as to the number or types of vehicles which might be sought for NASA missions. And we might want to discuss that later, and unfortunately no funding has been provided in the fiscal year 1988 budget to begin our mixed fleet program.

Now, last year this committee had considerable interest in what we then called the SR&QA, the Safety Reliability and Quality Assurance program. We now call it Safety, Reliability, Maintainability and Quality Assurance, (SRM&QA) program, and it has been consolidated and expanded under a new Associate administrator, George Rodney, with an increased fiscal year 1988 budget request of $16.2 million for studies and technical assessments not tied directly to a specific NASA program.

This, as you may notice, is double the amount we had in fiscal year 1986 for these activities. Additionally this does not count, by the way, the people. That is an R&PM budget, and that has increased much more dramatically than the actual dollars for the studies. Additional funding is planned in part to revitalize NASA's basic safety program and to create an agency-wide systems assurance function, which among other things will provide a capability for problem reporting, corrective action and trend analysis. That will use the past experience to give some feeling about what we can rely on and what we can't.

The broad data base provided by this system will generate information to be used for design fleet and test reviews and will be accessible to NASA and its contractors on an iterative basis. That is, we will keep feeding it back into the program. Its trend analysis capability will provide more complete illumination of problems for senior management at all levels, including headquarters.

Major new initiatives are also underway in risk management policies and assessments. Advanced nondestructive evaluation techniques, failure modes and effects analysis, FMEA, as we call it, critical items list, hazard analysis and flight and ground operational safety.

Other objectives include the enhancement of contract provisions and incentive award criterion for SRM&QA and consolidation of SRM&QA functions at various NASA centers. It is a fairly big paragraph, but there was considerable interest last year, and we took heed of that. We have really tightened up our SRM&QA program.

The administration continues to place a high priority on the development of a permanently manned Space Station, and NASA's fiscal year 1988 budget request of $760 million for Space Station

supports substantial and steady progress in meeting the President's goal of an operational capability in the mid-1990s.

And I might just pause here for a minute, because there was considerable concern by some of you about the international aspect of that, and we had postponed our January meeting with our international partners, that is the European Space Agency, Canada and Japan, and we had scheduled a February 11 meeting again with those at the State Department to foreign minister level. I am happy to report that at 11:00 o'clock last night, we solved our problems with the space group, and the February 11 date still holds.

We are evaluating the results of an intensive review of Space Station estimated costs to assure that program and funding plans are actually consistent, and I know there is considerable interest in that. We are not quite ready to make an announcement that we have a number on that yet.

The Space Station symbolizes our national determination shared by the President, the Congress and the American public to remain undeterred by the tragedy and to continue to explore the frontiers of space.

In Space Science and Applications, NASA's budget continues to develop major projects to study the earth, the solar system and the universe. Although the Challenger accident has delayed the launch of all scientific missions anywhere from two to five years, they are important to science and the expansion of human knowledge remains unquestioned, and they will be launched as expeditiously as possible consistent with our capabilities.

Furthermore, we have developed a strategy to carry the Space Science and Applications program through the hiatus in Space Shuttle flights in a manner which will insure the maintenance of our critical science base and the continuation of first-class science, which has been the hallmark in past years of NASA.

Because of the diminished frequency of Shuttle launches, particularly in the early years of resumed flight, we are carefully considering the options for recovery of the planetary program. We will launch each mission as soon as practicably possible, consistent, of course, with the availability of appropriate additional expendable launch vehicles which are not yet funded.

The budget includes $25 million for the global geospace science (GGS) mission, a new initiative, which will support the full participation of the United States in the international solar terrestrial physics program, an important cooperative effort with the European Space Agency and Japan. The program will involve the launch of a series of space craft beginning in 1992 and operating through the decade to study the basic physics of the earth's magnetosphere and the solar terrestrial relationship.

The sun, as you know, gives off all kinds of rays in the earth's magnetospheric field, forms a plasma around the earth, and that is an important thing to understand that solar-terrestrial relationship.

In commercial programs, the fiscal year 1988 budget supports a greater emphasis on promoting commercial ground base activities through existing outreach initiatives, such as the technology utilization program, and the centers for the commercial development of space. I would like to say that the technology utilization program is

an old NASA program, and it is designed to aid non-aerospace companies develop new products and processes in the private sector. The thing that gives it additional importance perhaps, it is a basis for most of the similar initiatives described in the President's international competitiveness program.

In fiscal year 1988, a new civil space technology initiative (CSTI) will begin a major new effort to strengthen the Nation's technical base, and thereby its competitive posture. The program will be implemented in close cooperation with industry and with expanded university involvement. It includes research and technology for safe and efficient access to space, for earth orbiting operations and supporting science.

Moving to aeronautics, our program for aeronautics research and technology is focusing on emerging technologies aimed at maintaining U.S. leadership in aviation and enhancing U.S. industrial competitiveness.

Now, we have always at NASA emphasized aeronautics, and I think we are second to none in the world as an agency for developing new aeronautics technology. Our budget continues that excellence.

In fiscal year 1988, emphasis on our computational research will lead to advances in the design of aircraft and propulsion systems with the new soon-to-be dedicated numerical aerodynamic simulation capability that is now on line at Ames Research Center.

Also, promising results are expected in research aimed at highly maneuvering aircraft, technology in high temperature composite engine materials. These materials that will promise revolutionary advances in engine thrust-to-weight ratio and efficient supersonic cruise propulsion systems, not hypersonic.

In the still higher speed regime, we will continue with the development of technology for a hypersonic and transatmospheric flight in support of the national aerospace plane program in conjunction with the Defense Department. Particular emphasis is on lightweight thermal structures, high-speed propulsion, and development of the computational tools necessary for vehicle design and integration.

The fiscal year 1988 request for space tracking and data systems will provide for the continuation of the vital tracking command telemetry communications, data relay and data processing support to meet NASA's flight program, as well as advanced systems requirement.

We are making, as you know, Mr. Chairman, the transition from a ground-based tracking network to a space-based tracking capability for low-earth orbital missions which began with the TDRS 1. We lost TDRS 2 on the Challenger, as you may remember, and this program is continuing. The next two Tracking and Data Relay Satellites are scheduled for early launch when the shuttle operations resume in February, one in February, I think the first launch will be a TDRS, and the second one in September 1988. Those are tentative schedules, of course.

The proposed fiscal year 1988 construction of facilities program will continue to preserve and enhance NASA's facilities so as to maintain our research, development, and testing capability and their effectiveness.

This budget includes key facility requirements for Space Station development, essential institutional requirements for R&D, testing and operational support and initial increment of a program to assure environmental compliance. This has been plaguing NASA for some years, and we have decided to just go ahead and do it, because we have some facilities that just don't comply with the local requirements, and we decided to go ahead and start the program of compliance.

The furthering and strengthening of our facilities base is a prerequisite in NASA's continuing contribution to the nation's overall technical competitiveness.

Moving to the institutional area, we will be taking two major steps in fiscal year 1988, continuing implementation of the organizational changes we announced on January 9, and increasing the number of NASA civil service personnel in certain critical areas, and SRM&QA is one of those.

The revised NASA organization reflects the results of the six-month management study headed by General Phillips under the auspices of the National Academy of Public Administration that made an objective and comprehensive assessment of NASA's management practices and their overall effectiveness. The study's recommendations are designed to improve the management of our technical programs of our institution, that is the people, facilities and equipment, and that includes the human resources program, which we are in the process of augmenting.

The actions we have taken and will be taking to implement the changes recommended will strengthen our organization enable us to focus more clearly on our goals and objectives and achieve what we set out to do more efficiently and more effectively.

In closing, Mr. Chairman, I would like to state that the high level of support that NASA has received from this committee, particularly over the past year, which as you say has been a trying one, has been invaluable in the successful implementation of our recovery program. NASA is very grateful for that support and for the support it has received from the Congress as a whole and from the American people.

Today, more than ever, NASA is determined to be worthy of that support. With renewed dedication to excellence, we will strive to make America proud of us and our program and to maintain our leadership in aeronautics and space. The American people deserve and expect no less.

Mr. Chairman, that completes my statement. I would be pleased to respond to any questions, or if I can't, Mr. Myers, Mr. Newman or the team just behind me, we will try to do so.

[The prepared statement plus answers to questions asked of Dr. Fletcher follows:]

STATEMENT OF DR. JAMES C. FLETCHER, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Six months ago, when I accepted the Rogers Commission report on the Challenger accident, I pledged to take whatever actions necessary to make NASA a better organized, better managed, more competent, safer agency, thereby restoring the excellence that has been its hallmark for nearly three decades.

Today, I am pleased to report that NASA is well on the road toward realizing those goals. A year after the Challenger accident, NASA has turned the corner in

its recovery efforts. Difficult though this past year has been, it also has been a year of rebuilding, and a year of strengthened resolve to return the Nation to the forefront of space activities, safely and reliably. We have recently announced a comprehensive NASA management reorganization based on recommendations from the Phillips. We are continuing our Science and Applications and other programs so vital to the expansion of human knowledge. And we are further strengthening the technology upon which our leadership in space and aeronautics depends.

NASA's Office of Space Flight, at my direction, has recently completed an analysis of the role of expendable launch vehicles as a complementary launch capability to the STS to assure future U.S. access to space. The findings of the "mixed fleet study" are that expendable launch vehicles could provide a viable and necessary augmentation in the overall launch capabilities of the U.S. Government. However, no final policy determination has been made as to the number or types of vehicles which might be sought for NASA missions.

The Administration continues to place a high priority on the development of a permanently manned Space Station, and NASA's FY 1988 budget request of $767 million for Space Station supports substantial and steady progress in meeting the President's goal of an operational capability in the mid 1990s. The Space Station is essential to regaining a position or leadership in space for the United States. Its practical benefits will be many—it will be orbiting laboratory for the conduct of science, the development of new technologies, and the stimulation of commercial enterprises. It will provide a facility in space to service and repair spacecraft. It will function as a transportation depot from which spacecraft can depart to geosynchronous orbit and beyond. The lessons learned from operating the Space Station in the 1990s—in life sciences, microgravity sciences, technology, and assembly of large structures—are necessary prerequisites to any future long-duration manned exploratory mission.

Symbolic values of the Space Station, however, may exceed its considerable practicality. It represents the commitment of the United States to a future in space. This future will be intellectually rigorous, technically demanding, and commercially profitable. With the positive response to President Reagan's invitation to friends and allies of the United States to participate in the program, the Station symbolizes our Nation's desire to cooperate with others in mutually beneficial civil space activities. With the Soviet Union already operating two orbiting stations, the Space Station symbolizes the intent of the United States to be second to none in utilizing the diverse capabilities of a permanent human presence in space. Perhaps most importantly, as we steadfastly recover from the loss of Challenger and her crew, the Space Station symbolizes our national determination—shared by the President, the Congress, and the American public—to remain undeterred by the tragedy and to continue to explore the frontiers of space.

The Space Station Program itself, in the past six months, has made substantial progress, and I am confident we are now on the right track. We have completed an extensive, 21-month definition and preliminary design study, supplemented by a critical evaluation of the Station's configuration conducted by a special NASA task force. We have completed a three-year effort in technology development, extensively examined operational factors, and restructured the Program's management. In response to Congressional directives, we have baselined a man-tended capability early in the assembly process, provided for the accommodation of early payloads, and initiated a flight telerobotic servicer program. We have also studied the related subjects of Space Station safety and crew rescue, involved the user communities in design activities and made progress in the international negotiations which will define the Space Station partnership during hardware development and operations. In addition, we are evaluating the results of an intensive top-to-bottom review of Space Station estimated costs based upon the revised configuration to assure that the program and funding plans are fully consistent. For further confidence, we are proceeding with a Program Review by the NASA Advisory Council and an independent cost review. The result of all these activities should be a sound Space Station configuration and a solid understanding of design issues, which will enable NASA to undertake a successful development program.

In Space Science and Applications, NASA's budget continues to develop major projects to study the Earth, the solar system and the universe. Although the *Challenger* accident has delayed the launch of many scientific missions, their importance to science and to the expansion of human knowledge remains unquestioned, and they will be launched as expeditiously as possible, consistent with our capabilities. Furthermore, we have devloped a strategy to carry the Space Science and Applications program through the haitus in Space Shuttle flights in a manner which will ensure the maintenance of the science base and the continuation of the first class

science which has been the hallmark of NASA. Because of the diminished frequency of Shuttle launches, particularly in the early years of resumed flight, we are carefully considering the options for recovery of the Planetary Program. We will launch each mission as soon as practically possible consistent with vehicle availability. The FY 1988 request of $1508.3 million will provide necessary support to accommodate replanning of major flight projects and smaller payloads under the revised Shuttle manifest. It will ensure maintenance of our critical research base which will provide for exploitation of already operating missions as well as analysis of data from previous missions. The FY 1988 request also supports initiation of efforts to prepare for the Space Station era which is expected to increase the potential for scientific advances many fold; the initiation of the funding in this budget will ensure that we are in a position to make maximum use of the Space Station in the early stages.

The FY 1988 budget supports a viable program of science across the various disciplines, with many international partners. It provides for continued effort on the Hubble Space Telescope, scheduled for launch from the Shuttle in 1988; the telescope will enlarge the volume of the universe viewed by 350 times and will extend our vision back ten billion years, almost to the birth of the universe. It also supports continued development of other major projects, including the Gamma Ray Observatory; the Magellan mission to Venus; the Galileo mission to Jupiter; the Mars Observer; the Upper Atmosphere Research Statellite and the Ulysses Solar Observatory. The Cosmic Background Explorer, which will study the radiation from the birth of the universe, is scheduled for launch in 1989 from Vandenberg Air Force Base on a Delta rocket, which will enable launch of this most important scientific spacecraft only nine months later than planned prior to the *Challenger* accident. This budget also provides for the resumption of Space lab missions in early 1989.

The budget includes $25 million for the Global Geospace Science Mission, which will support the full participation of the United States in the International Solar Terrestrial Physics (ISTP) program, an important cooperative effort with the European Space Agency and Japan. The program will involve the launch of a series of spacecraft beginning in 1992 and operating through the decade, to study the basic physics of the Earth's magnetosphere and solar terrestrial relationships. The program will entail the most comprehensive study of the Earth's magnetosphere ever attempted and will increase our understanding of how incoming energy from the Sun is distributed, stored and released.

The FY 1988 budget does not include funding for the Advanced Communications Technology Satellite (ACTS), consistent with the proposed Administration rescission action totalling $26 million for FY 1987. The proposed rescission is part of the Administration's effort to avoid possible competition with the private sector and to minimize Government subsidies for activities more appropriately and effectively undertaken by the private sector.

In Commercial Programs, the FY 1988 budget supports a greater emphasis on promoting commercial ground-based activities, through existing outreach initiatives such as the Technology Utilization program. The use of NASA-developed technology terrestrially will aid non-aerospace companies by familiarizing them with the opportunities for future commercial space involvement. At the same time, it will assist both aerospace and non-aerospace companies already interested in space-based commercial development in future flight-related projects. The program will also support continuation of the Centers for Commercial Development of Space (CCDS), which conduct high technology space-related research aimed at the development of new products and processes having either commercial potential or contributing to new commercial ventures. We will also initiate a sounding rocket program to provide companies opportunities for brief weightless experiment time for projects with commercial potential during the Shuttle downtime and possibly thereafter.

In recent years, considerable concern has been expressed in Congress and elsewhere that this Nation may be, in effect, mortgaging its future is space by living off past technological achievements. In order to continue to ensure United States leadership in space technology, ongoing technology efforts in NASA's FY 1988 Space Research and Technology Program have been augmented by $70 million as part of a new Civil Space Technology Initiative (CSTI). The CSTI will begin a major new effort to strengthen the Nation's technical base and thereby its competitive posture, as well as to rebuild and restore NASA's technical strength. The program will be implemented in close cooperation with industry and with expanded university involvement. It includes research in technologies for safe and efficient access to space, for Earth-orbiting operations, and for supporting science. In transportation, launch vehicle propulsion research will be aimed at reusable, high-performance engines for next-generation vehicles, a new booster technology program will develop options for both liquid rocket hybrid and propulsion systems, and an aerobraking flight experi-

ment will demonstrate use of the atmosphere to slow a vehicle returning to Earth orbit at high velocities. Earth-orbiting operations capability will be enhanced through a continued and expanded effort in automation and robotics. Applications include autonomous systems for control of multiple subsystems in the Space Station; launch system software to replace routine, labor-intensive activities; robotics for remote assembly, repair and servicing of space vehicles; and high capacity power delivery. Supporting technology for science will include efforts in structures research, sensor research for Earth observations and astrophysics, and data research for onboard processing of imaging information. CSTI is an important first step in sustaining United States industrial competitiveness and leadership in space.

Our program of Aeronautics Research and Technology is focusing on emerging technologies aimed at maintaining U.S. leadership in aviation and enhancing U.S. industrial competitiveness. The FY 1988 NASA request for this program is $375 million. During the past year, the X-29 forward-swept wing completed the initial flight envelope expansion; industry began flight tests of the GE/NASA Unducted Fan engine; and significant progress was made in joint research with the Federal Aviation Administration addressing wind shear and collision avoidance systems. This year, flight testing will begin on an advanced high-speed turboprop and the X-wing research aircraft. In FY 1988, emphasis on our computational research will lead to advances in the design of aircraft and propulsion systems with the new Numerical Aerodynamic Simulation capability that is now on line at the Ames Research Center. Also, promising results are expected in research aimed at highly maneuverable aircraft technology and high-temperature composite engine materials—materials that promise revolutionary advances in engine thrust-to-weight ratio and efficient supersonic cruise propulsion systems. In the still higher speed regime, we will continue with the development of technology for hypersonic and transatmospheric flight in support of the National Aero-Space Plane program. Particular emphasis is on lightweight thermal structures, high-speed propulsion, and development of the computational tools necessary for vehicle design and integration.

The FY 1988 request of $967 million for Space Tracking and Data Systems will provide for the continuation of the vital tracking, command, telemetry, communications, data relay and data processing support to meet NASA's flight program, as well as advanced systems requirements. The transition from a ground-based tracking network to a space-based tracking capability for low Earth orbital missions, which began with the TDRS-1, is continuing. The next two Tracking and Data Relay Satellites are scheduled for launch when Shuttle operations resume in February and September 1988. TDRSS will be considered operational when three fully functioning spacecraft are in geosynchronous orbit, and the spacecraft and ground terminal have completed their individual and systems acceptance tests.

The proposed FY 1988 Construction of Facilities program will continue to preserve and enhance NASA's facilities so as to maintain our research, development and testing capability and effectiveness. This budget includes key pacing facility requirements for Space Station development, essential institutional requirements for R&D, testing, and operational support, and the initial increment of a program to assure environmental compliance. The nurturing and strengthening of our facilities base is a fundamental prerequisite in NASA's continuing contribution to the Nation's overall technical competitiveness.

In the institutional area, we will be taking two major steps in FY 1988: continuing implementation of the organizational changes we announced on January 9, and increasing the NASA civil service ceiling. The revised NASA organization reflects the results of the eight-month management study headed by General Phillips, under the auspices of the National Academy of Public Administration, that made an objective and comprehensive assessment of NASA's management practices and their overall effectiveness. The study's recommendations are designed to improve management of our technical programs, institution and human resources. The actions we have taken and will be taking to implement the changes recommended will strengthen our organization, enable us to focus more clearly on our goals and objectives and achieve what we set out to do more efficiently and more effectively.

The increase in our civil service ceiling of 625 workyears will bring our complement to 22,425 full-time equivalents. The 625 workyears will provide the increased staffing needed to implement the recommendations of review groups, including the Rogers Commission. The added people will be used in the areas of safety, reliability, quality assurance, program direction, and technical support, as well as to meet resource requirements of the Office of the Inspector General.

The funds associated with the additional civil service ceiling are in NASA's FY 1988 Research and Program Management request. The balance of the funds requested in R&PM will cover a continuation of current levels of support to our centers

and programs at anticipated price levels. This includes the research, test, operational and facility support and related goods and services necessary to operate efficiently the NASA installations, as well as the travel funds critical to the effective management and oversight of NASA programs. Funding of the NASA institution at the requested level is critical to providing the manpower and support needed for accomplishing NASA's space and aeronautics activities.

In closing, I would like to state that the high level of support NASA has received from this Committee, in particular, over the past year, has been invaluable to the successful implementation of our recovery program. NASA is very grateful for that support, and for the support it has received from the Congress as a whole as well as from the American people. Today, more than ever, NASA is determined to be worthy of that support. With renewed dedication to excellence, we will strive to make America proud and to maintain our leadership in aeronautics and space. The American people deserve and expect no less.

Mr. Chairman, this completes my prepared statement. I would be pleased to respond to questions you and other Members of the Committee may have.

Responses to Written questions submitted by Chrm. Roe.

QUESTION 1:

NASA is requesting $9.5 billion in Fiscal Year 1988.

a. What was the total amount you requested in your submission to OMB?

b. What was OMB's response?

c. Are yu satisfied that the FY 88 funding request for the Agency is adequate to support the Agency's programs?

d. Can you identify how much of the 88 budget will be used to support Shuttle recovery activities?

ANSWER 1:

a/b. Attached chart compares agency's request to OMB vs. the request to Congress for FY 1988 and provides explanations of differences.

c. The level of funding for NASA contained in the President's budget request represents a modest increase over the agency's funding level for FY 1987 after adjusting for the replacement orbiter. The budget supports the safe return of the Shuttle to flight, the start of the developmental phase of the Space Station, a continuation of the agency's programs in Space Science and Applications and Aeronautics, and includes important new initiatives in the areas of solar physics, space research and technology and a strengthening of the NASA institution through an increase of 625 positions in the civil service workforce.

d. The FY 1988 budget includes approximately $400 million in FY 1988 for Shuttle recovery activities. Of this amount, about $150 million is for corrective actions, testing and verification to permit resumption of flights. The balance is for implementation of additional actions needed to sustain a safe buildup of flight activity as identified in response to the Roger's Commission report.

QUESTION 2:

In about 2 weeks NASA will be giving us an indepth report on efforts to recover from the Shuttle.

a. The current estimates by NASA and the National Research Council of what sort of flight rates can be achieved and sustained by the Space Shuttle are at wide variance with each other. Can you please express your views on this subject?

ANSWER 2:

With a four orbiter fleet NASA projects a flight rate of 16 per year and the National Research Council (NRC) projects 12 per year. NASA and the NRC agree that four flights per year per orbiter is achievable. The NRC, however, makes the judgement that with a four

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1988 BUDGET

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | Δ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| RESEARCH AND DEVELOPMENT | 3127.7 | 4106.4 | -483.2 | 3623.2 | |
| Space Station | 420.0 | 1055.0 | -288.0 | 767.0 | Reduction consistent with early development schedule changes. |
| Space Transportation Capability Development | 495.5 | 570.4 | -1.8 | 568.6 | Adjustment to payload operations funding. |
| Space Science and Applications | 1552.6 | 1616.7 | -108.4 | 1508.3 | |
| Space Science | 983.4 | 987.4 | -38.4 | 949.0 | |
| Physics and Astronomy | 552.8 | 605.5 | -38.4 | 567.1 | |
| Hubble Space Telescope Development | 101.3 | 98.4 | 0.0 | 98.4 | |
| Gamma Ray Observatory Development | 50.5 | 49.1 | 0.0 | 49.1 | |
| Spacelab P/L Dev. & Mission Mgmt. | 98.1 | 96.8 | -1.4 | 95.4 | Adjustment to shuttle payload funding. |
| High Resolution Solar Obs Dev | 0.0 | 12.0 | -12.0 | 0.0 | Deletion of funds for proposed new initiative. |
| Explorer Development | 56.7 | 60.3 | 0.0 | 60.3 | |
| Mission Ops. & Data Analysis | 125.7 | 128.1 | 0.0 | 126.1 | |
| Research and Analysis | 53.4 | 85.1 | -25.0 | 60.1 | Deletion of $25.0M for AXAF Pathfinder ATD. |
| Suborbital Program | 75.1 | 75.7 | 0.0 | 75.7 | |
| Life Sciences | 72.2 | 74.6 | 0.0 | 74.6 | |
| Life Sciences Flight Experiments | 30.4 | 32.9 | 0.0 | 32.9 | |
| Research and Analysis | 41.8 | 41.7 | 0.0 | 41.7 | |
| Planetary Exploration | 358.4 | 387.3 | 0.0 | 387.3 | |
| Galileo Development | 71.2 | 55.3 | 0.0 | 55.3 | |
| Ulysses | 19.3 | 10.8 | 0.0 | 10.8 | |
| Magellan | 92.6 | 59.6 | 0.0 | 59.6 | |
| Mars Observer | 35.8 | 29.3 | 0.0 | 29.3 | |
| Mission Ops. & Data Analysis | 80.0 | 77.0 | 0.0 | 77.0 | |
| Research and Analysis | 60.5 | 75.3 | 0.0 | 75.3 | |

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | Δ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| **Space Applications** | 569.2 | 629.3 | -70.0 | 559.3 | |
| **Solid Earth Observations** | 75.6 | 76.8 | 0.0 | 76.8 | |
| Shuttle/Spacelab Payload Development | 21.6 | 21.1 | 0.0 | 21.1 | |
| Applied Research, Data Analysis and Related Activities | 54.0 | 55.7 | 0.0 | 55.7 | |
| **Environmental Observations** | 320.9 | 393.8 | 0.0 | 393.8 | |
| Upper Atmospheric Research Satellite | 110.2 | 95.6 | 0.0 | 95.6 | |
| Shuttle/Spacelab Payload Development | 12.0 | 19.4 | 0.0 | 19.4 | |
| Applied Research, Data Analysis and Related Activities | 142.8 | 141.3 | 0.0 | 141.3 | |
| Scatterometer | 32.9 | 22.7 | 0.0 | 22.7 | |
| Ocean Topography Experiment | 19.0 | 90.0 | 0.0 | 90.0 | |
| Global Geospace Science | 0.0 | 25.0 | 0.0 | 25.0 | |
| **Materials Processing** | 47.9 | 45.9 | 0.0 | 45.9 | |
| **Space Communication** | 103.5 | 99.5 | -70.0 | 29.5 | |
| Search and Rescue Transition | 1.0 | 1.3 | 0.0 | 1.3 | |
| Adv. Comm. Tech. Satellite Development | 85.0 | 70.0 | -70.0 | 0.0 | Consistent with FY 1987 rescission. |
| Applied Research, Data Analysis and Related Activities | 17.5 | 19.2 | 0.0 | 19.2 | |
| **Information Systems** | 21.3 | 22.3 | 0.0 | 22.3 | |
| **Commercial Programs** | 41.3 | 54.0 | 0.0 | 54.0 | |
| Technology Utilization | 15.7 | 18.3 | 0.0 | 18.3 | |
| Commercial Use of Space | 25.6 | 35.7 | 0.0 | 35.7 | |
| **Aeronautical Research and Technology** | 376.0 | 385.0 | -10.0 | 375.0 | |
| Research and Technology Base | 272.9 | 285.2 | 0.0 | 285.2 | |
| Systems Technology Programs | 103.1 | 99.8 | -10.0 | 89.8 | Deletion of funds for High Alpha Technology. |
| **Transatmospheric Research and Technology** | 45.0 | 66.0 | 0.0 | 66.0 | |

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | Δ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| Space Research and Technology | 171.0 | 325.0 | -75.0 | 250.0 | |
| Research and Technology Base | 133.6 | 115.0 | 0.0 | 115.0 | Reduction of funds for CSTI program. |
| Systems Tech Program | 37.4 | -- | -- | -- | |
| CSTI Program | -- | 154.1 | -20.0 | 134.1 | |
| Pathfinder | -- | 55.0 | -55.0 | 0.0 | Deletion of augmentation directed at enabling technology for future missions. |
| Safety, Reliability and Quality Assurance | 9.2 | 16.2 | 0.0 | 16.2 | |
| Tracking and Data Acquisition Advanced Sys | 17.1 | 18.1 | 0.0 | 18.1 | |
| SPACE FLIGHT, CONTROL, AND DATA COMMUNICATION | 5815.0 | 4064.3 | 0.0 | 4064.3 | |
| Shuttle Production & Capability Development | 1885.1 | 1229.6 | 0.0 | 1229.6 | |
| Replacement Orbiter | 2100.0 | -- | -- | -- | |
| Space Shuttle Operations | 1847.0 | 1885.8 | 0.0 | 1885.8 | |
| Space and Ground Networks, Communications and Data Systems | 862.9 | 948.9 | 0.0 | 948.9 | |
| RESEARCH AND PROGRAM MANAGEMENT | 1425.0 | 1634.0 | -36.0 | 1598.0 | -30.4M for new initiatives and augmentations, -5.6M reestimate of FERS. |
| CONSTRUCTION OF FACILITIES | 166.3 | 219.6 | -24.1 | 195.5 | -17.8M for Large Spacecraft Lab at LaRC; -6.3M for Mods to Atmospheric Reentry Materials and Structures Evaluation Fac at JSC. |
| TOTAL NASA | 10534.0 | 10824.3 | -343.3 | 9481.0 | |

orbiter fleet only three of the four will be "manifestable". Thus, they project 12 flights per year. This judgement is predicated on unpredictable occurrences that in effect will remove one of the four orbiters from use. The NASA projection is based on analyses and experience that supports the view that each of the orbiters may fly four times a year.

QUESTION 3:

A recent major study within NASA concluded that the Agency should begin making extensive use of expendable launch vehicles as a complement to the Space Shuttle.

a. This committee has urged NASA to procure launch services from the commercial sector to launch government payloads, "FOB ON-ORBIT" if you will.

- What progress has the Agency made toward this end?
- Do you believe the commercial sector can handle all NASA's payload requirements?
- Are there any impediments (e.g., procurement, insurance) that you currently foresee to utilizing commercial launch services?

ANSWER 3:

The major study concluded in December 1986 was a NASA Mixed Fleet Study for launching approved and planned NASA missions. Primarily, the study covered a near-term time frame of 1988 to 1995 and concluded that a mixed fleet, composed of the shuttle and expendable launch vehicles, was necessary to assure access to Space.

Since December 1986, NASA is initiating a Request for Proposal (RFP) to ELV manufacturers for the procurement of launch vehicles and launch support of Weather Satellites, GOES-I, -J, and -K to be launched beginning in 1989 on an annual basis. The details of how this procurement will be structured is yet to be established and we will keep you informed as this action develops.

In addition, with the selection of the Delta vehicle to support the DOD's GPS missions, a solid base has been established to insure a continuing ELV availability for insured access into Space. The McDonnell Douglas Corp., the producer of the Delta vehicle, is negotiating with commercial and international agencies to provide launch services to them. Further, Martin Marietta Corp., the producer of the Titan vehicle is also negotiating with a number of commercial operators to provide them with launch services. We are encouraged that between the commercial sector and the DOD capability, NASA payloads requirements can be met.

For the last three years, NASA has been working with various government agencies, DOT, DOD, and the DOC, to implement the privatization of ELV's. Many of the problems concerning procurement, insurance, shared use of government facilities with private companies, liability, etc. are being investigated and addressed. We believe that these impediments can all be resolved.

QUESTION 4:

The National Commission on Space has recommended that we establish a National Space Laboratory to be responsible for planning and coordinating space-based laboratory facilities. What is your view of this proposal? How can we otherwise coordinate the space related activities of NASA, DOE, NOAA, USGS, and other agencies?

ANSWER 4:

The Commission's recommendation is for an administrative entity known as the National Space Laboratory (NSL) with responsibilities that include:

- Planning for space-based laboratory facilities
- Selecting scientists to use the facilities
- Advise facility managers in order to maximize scientific productivity

The recommendation may present some difficulties in its implementation since the NSL would not have funding and/or programmatic responsibility for the facilities. NASA's experience in coordinating space programs involving domestic and international participants have shown both the difficulty and complexity of such an effort even when NASA had control of the program and funding. Throughout the lifetime of the programs, there is a constant interrelated coordination activity between contractors, launch schedules, scientific investigations, etc.

QUESTION 5:

One of the concerns raised by this Committee in the investigation of the Challenger accident was the lack of a rigorous approach to determining reliability of Shuttle hardware. The FMEA (Failure Modes and Effects Analysis) identifies what can go wrong, but doesn't address the probability of failure. What is NASA doing to correct this?

ANSWER 5:

NASA is initiating a demonstration project to determine what additional information the probabilistic risk assessment (PRA) would add to the current FMEA/CIL and Hazard Analysis (HA) process. The objective is to determine whether the PRA identifies areas requiring design or operational considerations that the FMEA/CIL and HA's failed to identify. This demonstration project will analyze the Orbiter auxiliary propulsion unit and main propulsion system pressurization system and will compare the results with the results from the other analyses for these systems. Each analysis will be performed by a separate, independent organization that is experienced in the PRA process.

NASA is also evaluating the concern that critical items are not prioritized to highlight those items which may be most significant or most likely to occur, and the management attention is required to be devoted to all items uniformly rather than be focused on the most significant. The NSTS Program has been pursuing Critical Items

List (CIL) prioritization techniques for some time and several approaches are under consideration. The program, with Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) participation, is reviewing each of the candidate techniques with the objective of selecting a method or hybrid method derived from the salient features of each. Once a method is selected, the candidate system will be validated with a test in each project element and then be presented to the Program Requirements Control Board (PRCB) for program baselining.

QUESTION 6:

The National Research Council has recommended that Criticality 1 and 1R items should be assigned priorities based on probability of occurrence. Is this being done?

ANSWER 6:

The CIL items, including Criticality 1 and 1R items, will be assigned priorities in accordance with the method which is baselined by the PRCB (see Answer 5). As part of the review process to select and baseline the prioritization system, consideration is being given to utilizing the probability of occurrence, as well as criticality of failure, design confidence and redundancy in assigning the priorities. A demonstration project is being initiated to determine the added value of the probablistic risk assessment approach. The demonstration project will analyze the Orbiter auxiliary propulsion unit and main propulsion system pressurization system.

QUESTION 7:

You have established three categories for changes to the Shuttle: those required before the first flight because the current design may not contain a sufficient safety margin, those to be implemented in the near term to increase the safety margin, and those that can be approved in the normal project and program control boards and implemented as they become available?

a. How did you define "sufficient safety margin"?

b. What methodology was used to determine whether the safety margin was "sufficient"?

c. How does this differ from what was done before to determine acceptable level of risk? (See question #5).

ANSWER 7:

a. In general, the safety margin is defined as sufficient if the design meets or exceeds the specified design safety requirements. For example, structural components and pressure vessels are required to be designed to a specific factor of safety. Orbiter avionic equipment is designed to be fail operational/fail safe. All components must be capable of operating safely in the natural and induced environments to which they are subjected.

b. The methodology used to determine whether the safety margin is sufficient is that the design meets or exceeds the specified design safety requirements.

c. The basic methods used to determine the acceptable level of risk are essentially the same as utilized previously, however, the entire system is being re-analyzed in the light of flight experience including the Challenger accident. In order to focus attention on the most significant items, it is planned to baseline and implement a prioritization system.

QUESTION 8:

What do you presently see as the appropriate mix of ELV's and Space Shuttle assets to give our civil program assured access to space?

ANSWER 8:

Based on the completed NASA Mixed Fleet study, the ELV Family of Vehicles (Titan, Atlas and Delta), along with the shuttle can satisfy the needs of the Nation's civil program. However, additional budgetary support maybe necessary to procure expendable launch vehicles and launch operations support to meet these needs.

These vehicle launch services will be procured competitively from the private sector whenever they are available on a commercial basis.

QUESTION 9:

It is our understanding that a recent National Security Decision Directive issued by President Reagan would bar NASA from procuring hardware but would allow NASA to procure commercial ELV launch services. As you know, the concept of procuring launch services was endorsed by the Congress in the NASA authorization act last year.

a. Do you intend to issue RFp's for commercial launch services in the near future?

b. Does NASA support the policy contained in this NSDD?

ANSWER 9:

a. NASA is stilling evaluating its launch needs. The studies should be completed in the very near future. The agency may well contract for commercial services, but the budget has not been allocated for this purpose.

b. NASA has always supported the development of a commercial ELV industry. This directive is consistent with earlier policy and the agency supports it.

QUESTION 10:

What is your view of the current state of the objections and concerns voiced by the NRC on the redesign effort underway on the STS Solid Rocket Boosters? When do you expect this issue to be resolved?

ANSWER 10:

The NRC has submitted three formal letter reports containing observations, concerns, recommendations and conclusions based on their reviews of the redesign effort over the past year. NASA has taken action, or has under study, all of the recommendations made by the Panel both formally and informally. All of their concerns have been addressed in briefings or meetings with both the full Panel or individual Panel members or are subjects for review and discussion at future meetings. The Panel's inputs have been extremely helpful and, although critical at times, very constructive. Discussions on specific concerns or issues are addressed on a continuing basis. When a decision must be made it has (and will) be made after full consideration and review of the Panel's concerns and recommendations.

QUESTION 11:

One of the things that was obvious in both the investigation by the Rogers Commission, and in the investigation conducted by this Committee last year was that pressure to attain high launch rates caused NASA to discount valid safety concerns in favor of launch schedules. Why is NASA planning to press ahead with the first launch next February before all of the testing on the redesigned SRB's is complete and fully analyzed?

ANSWER 11:

Prior to the first flight, a series of tests of the redesigned solid rocket boosters (SRB's) will be conducted which include; 1) sub and full scale case-to-case and nozzle-to-case joints; 2) a full scale structural test article; and, 3) five full scale static test firings. This series of tests along with analysis will be successfully completed before the SRB's are considered safe for flight.

QUESTION 12:

You have also announced that you will modify the existing Orbiters to install an emergency crew escape system and a "blow-off" crew escape hatch, why are you proposing to go ahead with the first launch before the crew escape can be installed?

ANSWER 12:

Work to incorporate the system has been approved and is currently proceeding with the goal of meeting the first flight. The existing side hatch will be modified for pyrotechnic jettison. Personal crew survival equipment consisting of parachutes, pressure garments, air supply packs and water survival equipment is being developed.

Development of the rocket personnel extraction system is continuing and the risk versus added safety factor for possible incorporation of this feature into the Orbiter is being assessed. In addition to the rocket extraction system, several options to improve the potential for avoiding recontact in the manual mode are being

evaluated. These include a slide concept and an extendable rod and/or rope concept.

The overall schedule for incorporation of the escape system is currently under review and pending completion of the review, a decision will be made as to the official first flight effectivity of the system.

QUESTION 13:

In the past the Committee has been repeatedly told that the Space Station would cost $8 billion in 1984 dollars, and would reach IOC by 1994. In testimony before the other body earlier this week you raised that cost to $13 billion and said that IOC would be "in the mid-90's." We understand that within NASA a strong and viable argument has been made that the figure could be as high as $15 billion. What is going on here?

ANSWER 13:

The NASA Administrator directed that a major program cost review of the Space Station be undertaken in order that he, the Administration and Congress have available a current and comprehensive analysis of Space Station cost, capability and schedule. This review was conducted. Its results are being discussed with senior Administration officials. NASA expects to be able to discuss the review with the Committee shortly. The program cost review will update the $8 billion estimate, which was a preliminary estimate made in 1983. NASA's plan, then and now, was to review Space Station program data, including cost data, with the Committee at the conclusion of the Phase B definition and preliminary design effort, prior to initiating Phase C/D detailed design and development.

QUESTION 14:

Exactly which civil governmental payloads scheduled to be launched between now and 1995 could be launched on a:

Titan II
Titan III
Titan IV
Delta
Delta II
Atlas

And what is the estimated cost of each launch vehicle?

ANSWER 14:

14a. A number of civil government payloads initially scheduled to be launched on the shuttle could be launched on an ELV between now and 1995 are:

| NOAA Payloads | Planned Launch (FY) | ELV Vehicle That Could Be Used |
|---|---|---|
| LANDSAT-6 | 1989 | Titan II |
| NOAA-D | 1989 | Atlas, Titan II |
| NOAA-I | 1990 | Atlas, Titan II |
| GOES-I | 1990 | Titan III, Atlas/Centaur |
| GOES-J | 1990 | Titan III, Atlas/Centaur |
| NOAA-J | 1991 | Atlas, Titan II |
| GOES-K | 1992 | Titan III, Atlas/Centaur |
| **NASA Payloads** | | |
| TDRS-E | 1989 | Titan III/IV |
| TDRS-F | 1991 | Titan IV |
| TDRS-G | 1992 | Titan IV |
| MARS OBSERVER | 1990 | Titan III |
| PLANETARY | 1991 | Titan IV |
| ROSAT | 1989 | Atlas/Centaur, Delta, Titan III |
| CRRES | 1990 | Titan IV |
| MSAT | 1991 | Delta |
| EUVE | 1991 | Delta |
| GEOTAIL (ISTP) | 1992 | Delta |
| WIND (ISTP) | 1992 | Delta |
| RADARSAT | 1992 | Titan III |
| POLAR | 1992 | Delta |

14b. The estimated cost of each vehicle is as follows:

| Vehicle | Est. Cost |
|---|---|
| Titan II | $ 50.0M |
| Titan III | 142.0M |
| Titan IV | 171.0M |
| Delta (3920) | 38.0M |
| Delta II | 38.0M |
| Atlas-F | 15.0M |
| Atlas-H | 40.0M |

Notes:
1) Estimates for above vehicles are at rates of 4 per year in 1986 dollars. Includes vehicle hardware, launch services, contractor and government support.
2) Cost of upper stages not included in the estimated cost.
3) Unique effort and integration cost with spacecraft not included.
4) Atlas-F is a refurbished existing Atlas assuming DOD provides the government and contractor support through FY 1989, and Atlas-H is a new Atlas with all government and contractor support included in the estimate.

QUESTION 15:

The Committee has been informed that the Administration policy on the procurement of ELV hardware is limited to national security missions, and that "NASA will not maintain an ELV adjunct to the STS." We are also informed that NSDD 254 authorizes NASA to "contract for necessary ELV launch services." How do you intend to implement a mixed-fleet strategy within those policy limitations?

ANSWER 15:

NASA plans to operate within the Policy Directive NSDD 254. If there is a need for additional NASA capacity for civil government launches, NASA will contract with the DOD or with commercial operators for necessary ELV launch services.

QUESTION 16:

With regard to the Space Station, what is your current estimate of the life-cycle costs of the Space Station, and what do you expect annual operating costs to run during the first ten years of operations?

ANSWER 16:

The life cycle cost of the Station will be a function of both the development cost and the Station's useful life. A development cost estimate will be reported to the Congress shortly. In performing operations cost related analyses, we are using a twenty-year lifetime. A very preliminary estimate as a result of the recent program cost assessment is an annual operating cost of $800 million to $1.1 billion (in FY 1984 dollars). These figures do not include the cost of services provided by other NASA organizations, such as transportation to and from orbit. A ten-year estimate of mature operations costs, appropriately discounted. This estimate will be modified as we further define and solidify our operations plans.

QUESTION 17:

We are aware that some members of the astronaut corps have left the program since the Challenger accident. Will you provide the Committee with a listing of those who have left the Astronaut Office, and their current status.

ANSWER 17:

Since the Challenger accident, 10 members of the astronaut corps have left the program. The group of 10 astronauts include 2 civilians and 8 military. Of the 8 military astronauts, 4 have returned to their respective services, 2 have retired, one has been reassigned within NASA, and one is deceased.

Specifically:

o Dr. Karl G. Henize (civilian), Mission Specialist for STS 51-F, resigned and is now assigned to Space and Life Sciences Directorate, Johnson Space Center, Houston, Texas.

o Dr. James D. van Hoften (civilian), Mission Specialist for STS 41-C and STS 51-I, resigned and is now working for Bechtel National, Inc., San Francisco, California.

o Col. Roy D. Bridges (USAF), Pilot for STS 51-F, returned to the U.S. Air Force and is now Commander, 6510th Test Wing, Edwards A.F.B., California.

o Col. John M. Fabian (USAF), Mission Specialist for STS-7 and STS 51-G, returned to the U.S. Air Force and is now Director of Space, DCS Plans and Operations, Headquarters U.S. Air Force, Washington, D.C.

o Cdr. Dale A. Gardner (USN), Mission Specialist for STS 51-A, returned to the U.S. Navy and is assigned to Headquarters U.S. Space Command, Peterson A.F.B., Colorado.

o Brig. Gen. Robert L. Stewart (USA), Mission Specialist for STS 41-B and STS 51-J, returned to the U.S. Army and is assigned to the U.S. Strategic Defense Command, Huntsville, Alabama.

o Col. Robert F. Overmyer (USMC), Pilot for STS-5 and Commander for STS 51-B, retired from the U.S. Marine Corps. Col. Overmyer is a consultant and is now working in the development of the Space Station crew module.

o Col. Joe H. Engle (USAF), Commander for STS-2 and STS 51-I, retired from the U.S. Air Force. Col. Engle's status is unavailable at this time.

o Col. Charles G. Fullerton (USAF), Pilot for STS-3 and Commander for STS 51-F, resigned from the Astronaut Corps and was reassigned as a Test Pilot for NASA at the Dryden Flight Research Facility, Edwards A.F.B., California.

o In May, 1986 Lt. Cdr. Stephen D. Thorne (USN), Astronaut Candidate, was killed in a private aircraft accident.

QUESTION 18:

What is the expected cost to integrate the Mars Observer Mission onto a Titan III to preserve a 1990 launch? What would be the anticipated cost to integrate a Titan IV/IUS for the Ulysses Mission for a 1991 launch? What is your expectation on the availability of hardware and the probability of making these launch windows?

ANSWER 18:

We are in the process of developing the cost estimates for integrating the Mars Observer Mission on a Titan III for a possible 1990 launch. Preliminary cost data is available for procurement of the Titan III commercially through Martin Marietta. The hardware costs are highly dependent on the total Titan manufacturing and launch rate. Until this is resolved, the following costings are applicable:

COMMERCIAL ESTIMATE

| | |
|---|---|
| Titan III Hardware | $92M |
| Integration of Mission | $25M |
| Launch Services | $25M |
| | $142M |

In addition, approximately $5 million will be required for spacecraft modifications and $21 million will be required for TOS upper stage modifications. We believe a Titan III could have been made available in time to support a 1992 launch.

Several months ago, we performed a study to integrate a Titan IV/Centaur for the Ulysses mission for a possible support of a 1990 launch. The cost at that time was approximately $250 million. The use of an IUS upper stage would not significantly alter this estimate. The availability and scheduling of a Titan IV for a possible support of a Ulysses mission for 1991 would have to be worked out with the DOD.

QUESTION 19:

As you may be aware, this Congress will be looking very carefully at the federal role in strengthening this country's position as far as international technological competitiveness and in developing mechanisms for optimizing use of our innovative technologies. NASA has had a hallmark program in technology utilization for more than twenty years. Could you describe for the Committee what your anticipated efforts will be in fiscal year 1988 in the area of technology transfer and commercialization of NASA technology in order to strengthen our economic security and improve our international competitiveness posture? Could you provide data for the record on NASA patent waiver applications and actions and other measures of technology transfer effectiveness?

ANSWER 19:

In FY 1988, NASA plans to undertake the following technology utilization efforts:

a. NASTRAN

NASTRAN, a NASA-developed finite element computer program, has already achieved broad use and application throughout U.S. industry in the computer-aided design and testing of a myriad of structures from automotive components to sky-scrapers, bridges, and industrial facilities. At present, over 100 domestic industrial firms have leased NASTRAN from the Computer Software Management and Information Center (COSMIC), sponsored by the Office of Commercial Programs at the University of Georgia. Moreover, NASTRAN has found extensive use by other government agencies, most notably in the Department of Defense, in the computer design and testing of naval and aircraft structures, for example. NASTRAN has thus become a national resource through its widescale use and application over the past 15 years since its original development at the NASA Goddard Space Flight Center in the late 1960's.

A recent survey of government and industry users, however, has shown that NASTRAN requires additional analysis capability development if it is to keep pace with the increasingly sophisticated and complex structures envisioned by the U.S. technical community...including NASA. Recently,

NASA requirements for an upgraded NASTRAN code was evident, for example, in the computer analysis performed by Marshall Space Flight Center (MSFC) in the design of a new O-ring seal joint for the SRB. It was noted that had COSMIC NASTRAN included an enhanced nonlinear capability, the task at MSFC would have been more readily achieved at lower cost. Through FY 1987 and FY 1988, the NASTRAN software will be updated.

b. Centers for the Commercial Development of Space (CCDS):

CCDS's are not-for-profit joint research and development institutions formed by commercial firms, academic and research institutions, and non-NASA government organizations. NASA offers financial grants for such institutions and provides scientific and technical data, expertise, cooperative activity with NASA field centers, and other forms of continuing assistance. NASA's CCDS program approach is to provide the initial stimulus to establish CCDS and to sustain them over a limited period of time. The overriding objective of the CCDS program is to accelerate space-related commercial potential by strengthening ties between federal R&D centers, U.S. industry, and universities.The CCDS Program represents an innovative and novel transfer point for sharing space sciences, applications, and technology with American industry. The potential payoff is increased international competitiveness by U.S. industry in new and emerging fields of biotechnology, automation and robotics, remote sensing, space power, materials and structures. Nine CCDS's have been established, to date, which have brought together 58 U.S. corporations, 22 universities, 6 non-NASA government organizations, and most NASA field centers in a cooperative technology-sharing program. In FY 1987 and FY 1988, NASA plans to establish more CCDS's for a total of 18 CCDS's.

c. Student Technology Transfer Agents:

The NASA Technology Utilization Program has sponsored a technology transfer experimental program at the University of Kansas to test the ability of candidates for advanced engineering degrees to serve as technology transfer agents. Selected degree candidates work with midwestern small and medium size manufacturing companies to identify specific product or process opportunities/problems in which NASA-developed technologies may apply. The student, jointly-sponsored by NASA and the industrial client, becomes knowledgeable about the applicable NASA technology through publications, written reports, and visiting NASA field centers as necessary to interact with NASA scientists/ engineers. He then conducts prototype development in the University of Kansas laboratory which is tested by the client firm for adoption. The company profits through solution of a real problem, the student gains a useful and meaningful hands-on experience in technology transfer and application, and NASA benefits through extended use or spinoff of its technology. To date, approximately eight graduate students have completed or are actively engaged in the program at the University of Kansas. This program will be continued and expanded through FY 1988.

d. Encouragement of Federal Scientists to Commercially Develop their REsearch:

P.L. 99-502, the Federal Technology Transfer Act of 1986, enacted in October 1986, already includes the mechanism for implementing royalty sharing with federal inventors. Moreover, the Act allows for the continuation of the granting of awards to federal employees in a manner similar to the NASA awards program authorized under Section 306 of the National Aeronautics and Space Act of 1958, as amended. Under such provisions, NASA can continue to recognize scientific and technical contributions by all employees without regard to the use of such contributions.

At present, NASA Headquarters has developed a preliminary method for implementing the royalty-sharing provisions of the Act. Since passage of P.L. 99-502, NASA has received royalties from licensed inventions which are currently being placed into a special account, pending final decision on methods of distribution and certain management decisions related thereto.

e. Science Entrepreneurs:

Effective May 1986, under the sponsorship of the Office of Commercial Programs, a group called RIMTECH (Research Institute for the Management of Technology) entered into an "experimental" joint affiliation between the Jet Propulsion Laboratory (JPL) and high-tech venture business primarily based in the southern California area. The program is designed to enable entrepreneurial technology companies, for a fee of $25,000 and annual sales of less than $250 million, to tap JPL for "new product development technology."

The program with JPL is seen by NASA as a unique effort to leverage the limited R&D budget of emerging technology firms. To date, seven (7) companies have enrolled in the program and as many as 30 are expected to do so by the end of calendar year 1987.

Complementing the above, for organizations with annual sales greater than $250 million, the "Technology Affiliates Program" is being developed for established companies. Participation in this program requires an initial investment of $50,000. This program is currently being implemented and a public announcement is planned for the very near future. Negotiations are currently underway with two large national firms to commence program implementation.

f. Technology Transfer Counselors:

In FY 1987, NASA will place counselors at each NASA field center to ensure the best possible assistance to industry seeking technology transfer information. In FY 1988, NASA plans to double the counselor manpower at the field centers.

Another measure of technology transfer effectiveness is the demand for NASA's Tech Briefs journal. Circulation has increased by about 60 percent over the past 2 years. There are currently over 128,000 subscribers and the number is growing by 5,000 to 8,000 per month.

NASA patent waiver information is attached for FY 1986 and cumulative statistics from FY 1959 through FY 1986.

QUESTION 20:

There has been some concern that NASA's emphasis on the manned space program and the national aerospace plane has impacted the development of large cargo space transportation systems. There have even been some falacious arguments which state that the national aerospace plane will serve to replace Shuttle payload capability. It is my understanding, however, that the payload capabilities of the national aerospace plane are rather small in comparison to the needs specified within our national security plans for example. Could you comment on this? Would you also delineate what you expect to be the NASA role in unmanned heavy-lift vehicle development?

ANSWER 20:

The lift capability of an operational National Aerospace Plane will not be known for several years hence, during which time formidable technical challenges are being addressed for a technology demonstrator airplane. These include engines, structures, and aerodynamic configurations. Since neither the Aerospace Plane nor other future space transportation systems have been designed, it is premature to comment on how the payload capabilities will compare. Furthermore, the very advanced technology required may not make it a viable candidate to compete with the mature rocket technology available in the late 90's and; thus, it probably will not be a competitor to rocket vehicles until sometime after the turn of the century.

NASA's role relative to a heavy-lift vehicle development is under discussion with DOD at present but no agreements have been reached.

QUESTION 21:

The Subcommittee on Energy Research and Development will be reviewing the DOE's programs in development of advanced nuclear power systems for space applications. As NASA develops its long range mission plans, would you explain to us the need in the civilian program for such power systems and what the country's options are for developing advanced power capabilities for future civilian space missions?

ANSWER 21:

As part of NASA's space leadership planning activities, we are examining applications of space nuclear power systems to twenty-first century civil missions. Power levels of interest range from a few kilowatts to megawatts of electric power. In the lower range, small nuclear reactors could permit new approaches to the conduct of planetary science, enhance the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF GENERAL COUNSEL
1959 THROUGH FISCAL YEAR 1986 WAIVER STATISTICS
FOR LARGE ENTITY (305 SPACE ACT) CONTRACTORS

A. Inventions reported under NASA contracts..... 36,415

B. Petitions for Individual Inventions made under a contract

1. Received..... 1,939

a. Domestic..... 1,271
b. Foreign..... 668

2. Granted..... 1,526

a. Domestic..... 1,007
b. Foreign..... 519

C. Petitions for Advance Waiver - all inventions made under a contract

1. Received..... 1,172

a. Domestic..... 757
b. Foreign..... 415

2. Granted..... 720

a. Domestic..... 462
b. Foreign..... 258

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF GENERAL COUNSEL
FISCAL YEAR 1986 WAIVER STATISTICS

FOR LARGE ENTITY (§305 SPACE ACT) CONTRACTORS

I. Petitions for Waiver to individual Inventions made under a LE contract

1. Petitions for waiver received* . . . . . 53
   a. Domestic. . . . . 32
   b. Foreign . . . . . 21

2. Petitions granted . . . . . 49**
   a. Domestic. . . . . 29
   b. Foreign . . . . . 20

3. Petitions denied . . . . . 0
   a. Domestic. . . . . 0
   b. Foreign . . . . . 0

4. Petitions withdrawn . . . . . 6
   a. Domestic. . . . . 3
   b. Foreign . . . . . 3

II. Petitions for Advance Waivers - applicable to all inventions to be made under a LE contract

1. Petitions for waiver received* . . . . . 42
   a. Domestic. . . . . 24
   b. Foreign . . . . . 18

2. Petitions granted . . . . . 57
   a. Domestic. . . . . 32
   b. Foreign . . . . . 25

3. Petitions denied . . . . . 0
   a. Domestic. . . . . 0
   b. Foreign . . . . . 0

4. Petitions withdrawn . . . . . 4
   a. Domestic. . . . . 2
   b. Foreign . . . . . 2

III. Other Statistics

1. Inventions reported by NASA LE contractors (other than SE small business and nonprofit organizations) . . . . . 447

2. Inventions embodied in patent applications in which NASA has a U.S. license under an individual petition for waiver of title*** . . . . . 39

3. Inventions reported during the year from contracts having advance waiver of title . . . . . 24

4. Inventions in which NASA has acquired a license during the year under contracts having advance waiver and in which the contractor has filed a patent application*** . . . . . 2

5. Applications ( ) Patents ( ) transferred to NASA after filing/issuance. . . 0

6. Voiding actions**** . . . . . 17

* A petitioner may request domestic rights only, foreign rights only, or both. A petition for both domestic and foreign rights is recorded as two (2) petitions.

** The petitions granted exceed the petitions received, in that the petitions granted are from more that one fiscal year.

*** If foreign patent applications were filed as well as a domestic patent application on the same invention, it is recorded as one (1) invention.

**** Voiding actions include the voiding of a waiver of title, either domestic and/or foreign. Entire waivers may be voided or portions of waivers may be voided in foreign waivers wherein the waiver recipient chooses to abandon and/or transfer the rights to less than all the countries.

IN ANALYZING THESE STATISTICS IT IS IMPORTANT TO DISTINGUISH BETWEEN
PETITIONS AND INVENTIONS

operation of small scientific and commercial earth-orbiting spacecraft, and power surface exploration vehicles.

At °the intermediate to high power level (50KWe to 6MWe), nuclear power becomes the system of choice for many missions. The vast majority of NASA missions that potentially will use nuclear power fall in this range. Large power systems will permit the use of high power electric propulsion which will reduce trip times and earth-to-orbit launch weight requirements. Nuclear reactors could provide the power needed for long-term storage of cryogenic propellants in space. The power to support humans on extended space flights and a lunar or planetary bases will require the use of nuclear power. Other potential missions include space station, space materials processing platforms and interplanetary missions.

Our studies have shown that the reactor and conversion system technology being developed in the joint NASA/SDIO/DOE SP-100 program will meet all of our identified intermediate to high nuclear power requirements. The current reactor/thermoelectric conversion system to be tested in the SP-100 program will be scalable to power levels up to several hundred KW. By coupling this reactor with advanced conversion systems being developed by NASA, single unit power levels of up to 500KWe will be achievable. Planning data suggests that the basic building block for permanent Mars and lunar base power systems will be about this power level. It is the judgment of the personnel involved in the program that the current SP-100 reactor can be scaled up, with no technology changes, to a size that would permit single unit power level of 2MWe. Replication of these units would permit the development of any size power system needed in the foreseeable future.

Mr. ROE. Thank you for your summary and your statement. We appreciate it.

As a housekeeping matter, George Brown, our colleague, could not be here this morning, but I would like to have unanimous consent to put into the record his statement at this time.

[The prepared opening statement of Mr. Brown follows:]

OPENING REMARKS OF CONGRESSMAN GEORGE E. BROWN, JR.

Mr. Chairman, I would like to welcome the NASA Administrator, Dr. James Fletcher, and his associates to this posture hearing on the Fiscal Year 1988 NASA budget. This dedicated team must be commended for manning the helm at NASA through some very difficult months. While the space agency has come a long way in recovering from the Challenger disaster, there still remains a long stretch of road to travel before NASA regains its firm footing.

At the outset, let me say that I am pleased with many aspects of the NASA budget. A 13 percent increase over the FY '87 budget, to $9.5 billion in FY '88 is certainly a healthy boost for NASA. Within this total budget, construction will continue on the Space Station with $767 million; the National Aerospace Plane will move forward with a contribution from NASA of $66 million; and the Space Research and Technology program will increase by more than $70 million as part of the new Civil Space Technology Initiative.

Although these developments are encouraging, I am concerned that NASA may still be suffering from some of the same pitfalls that existed prior to the Challenger disaster. Although the total FY '88 budget shows an increase of 13 percent, it does not represent a vigorous civilian space effort. First, space science in America is in a bleak situation. Secondly, the Pentagon's heavy handedness in the civilian space program is threatening Space Station negotiations with Europe and Japan. And finally, the President has failed to provide the leadership necessary for a strong space program.

This year's NASA budget request is a disappointment to those of us concerned about space science. The Office of Space Science and Applications budget is in a state of crisis according to NASA's Space and Earth Science Advisory Committee. The FY '88 budget perpetuates a decade-long erosion of NASA's space science program. I fear the U.S. is relinquishing its lead in space science to Japan, India, Europe, China, and the Soviet Union.

A regrettable example is the decision to delay the launch of the Mars Observer from 1990 to 1992. This short-sighted decision will delay future planetary missions; impact on cooperation with two Soviet Mars missions; and could increase the overall cost by as much as $100 million. Every effort should be made to keep this program on schedule, even if that means procuring an expendable launch vehicle to do the job.

I am also seriously concerned about the ACTS program which has been consistently undermined by the Administration. In the 100th Congress, where "competitiveness" is a priority issue, ACTS is a program that can directly improve our position in the global telecommunications place. In the FY'88 budget, Congress is again placed in a difficult position of finding the funds necessary to keep the ACTS program alive. I sincerely hope that in the future the Administration will provide support for this worthy and important program.

The Space Station budget request of $767 million is encouraging. It is possible, however, that the volatile nature of negotiations with the Space Station's international partners could result in reduced Congressional support for the program.

As stated by many observers both inside and outside of government, NASA is operating in a leadership void. Without a clear set of goals and objectives, such as those articulated by the National Commission on Space, the space program will continue to flounder. The Administration has been negligent in its duty to provide the leadership needed to pull the space program out of its present crisis. I recognize that NASA has studies underway for strategic long-term planning, but unless the President endorses a comprehensive, forward-looking space policy, NASA's effort could be wasted.

Mr. Chairman, I think the public would approve of a NASA budget which demonstrates true commitment to the exploration and development of orter space. I am not convinced the budget we have before us today embodies that vision.

I look forward to working closely with the Subcommittee on Space Science and Applications and with NASA, arriving at a budget that reflects a strong space program and one that is worthy of "the Challenger Seven."

Thank you Mr. Chairman.

The chair defers to the distinguished chairman from New Mexico.

Mr. LUJAN. Thank you very much, Mr. Chairman. Yes, I do have several questions, and in my five minutes I will try to get in as much as I can.

Are there things that need tending in space? By that, I mean, you say the second TDRS will be launched in February, and another one in 1988?

Dr. FLETCHER. September.

Mr. LUJAN. The present one there, is it ailing? Is it in good shape, winding down?

Dr. FLETCHER. Mr. Lujan, I think it is only honest to say it is in marginal condition. There are parts that have failed. We can't count on it for a long-term mission. That is why it is important to get two more up there as soon as possible.

Mr. LUJAN. Are there other things that need tending up there in addition to TDRS?

Dr. FLETCHER. TDRS is by far the most urgent. There are other spacecraft in various conditions of ailment, but by and large they have lasted much longer than we had expected. I think TDRS would be the only one I would mention as in severe difficulty.

Mr. LUJAN. If we couldn't launch in February or even through 1988, which God forbid, can we re-make the satellite so we can launch it without a lot of difficulty?

Dr. FLETCHER. That is a very good question, and we are looking at an option for doing just that because the Shuttle schedule is not firm. We have a target date of February. TDRS is absolutely required, and we are looking at—by the way, it can be put on an expendable launch vehicle, we know that, but we don't have the expendable launch vehicle. Those are in short supply in this period. We are definitely looking at that option.

Mr. LUJAN. That is one of our priorities to get TDRS up there.

Dr. FLETCHER. Yes indeed.

Mr. LUJAN. The interim Shuttle, is NASA serious about a Shuttle between now and the aerospace plane, some interim step there?

Dr. FLETCHER. Mr. Lujan, we are studying, some people call it Shuttle II, it is an advanced shuttle. It is part of a longer look at transportation problems in the period late 1990s, early 2000 because the Shuttle isn't expected to last much beyond 2000. So we have as part of that study two different pieces, one a way to transport people to and from space, which the Shuttle does very well, and it is the only way we have right now; and the other part of it is to transfer cargo to and from space, which the shuttle does, but it kind of does both, and we are looking now for two separate transportation systems, one for people—we call that Shuttle II, there may be a different name for it, but that is our name for it—and the other one is called the heavy lift launch vehicle, because the chances are it will be able to carry much heavier payloads and thereby save some costs to orbit.

Mr. LUJAN. I would like to get some questions in real quick. My next one would be about the Mars observer. I don't know why it has developed so much interest and so many letters into at least

my office, and I assume to all the Congressional offices, any chance of it being scheduled back into 1990 rather than the postponement to 1992?

Dr. FLETCHER. We would very much like to schedule that in 1990 for a lot of reasons. One is that it was scheduled to have been ready by then. For another reason, the Russians are planning a rather sophisticated operation on Mars in, I think it is 1988 is their plan, and we would like to get back to Mars to measure the surface chemistry. We didn't do a good job of that with those two robots that we landed back in 1976. We really need to get back and investigate that planet.

I might just add, there is a great interest all of a sudden in Mars generally because it is now realized, due to analyses by scientists and so forth, that is the most inhabitable other planet. I don't think it is as good as the earth, but the most likely to be inhabitable other planet in our solar system, and some day we will be living there.

Mr. LUJAN. Any discussion in doing it with the Russians?

Dr. FLETCHER. We have had a lot of discussions among ourselves but not with the Russians.

Mr. LUJAN. If we give up Star Wars, they will do it.

Dr. FLETCHER. I can't comment on that.

Mr. LUJAN. That is the message we got when we were there. We will do a lot of things, but you guys give up Star Wars, and we will work with you.

One final question, and perhaps more of a comment, on the health of the commercial ELV program. As you know, this committee has repeatedly urged the commercialization of anything that we possibly can, and some of the stumbling blocks that I see, one is the liability that NASA is talking about for contractors, that they are responsible for everything, even if a NASA employee does something wrong. That is my understanding. It is like saying to TWA, if there is an accident that is caused because of an air traffic controller, you bear the responsibility, and they can't buy insurance. So you might want to look at that. That is one of the things that we are told that is part of the problem.

In addition to that, not everyone in NASA is enthusiastic about commercialization of the ELV program.

Dr. FLETCHER. I think I should comment, Mr. Lujan, we are working commercialization of ELVs very hard, and the legal questions, the liability questions that you mention are under intense study by our general counsel, who is here with us and can give you details. These are not trivial questions being brought up, but we are working them as hard as we can.

Now, with regard to the people not exactly enthusiastic about the commercialization of the ELVs, I think most of NASA is behind that program. We wish it would speed up so we could buy some of them, because we really need ELVs ourselves for some of our programs. The sooner they become available, and hopefully they will lower the cost, the better we will all be.

Mr. LUJAN. Thank you.

Mr. ROE. Thank you.

The chair recognizes the gentleman from Louisiana, Mr. Hayes.

Mr. HAYES. Dr. Fletcher, I notice you have quite a number of new people with you. Do you expect them to contribute substantially to NASA?

Dr. FLETCHER. We have a number of new people with us.

Mr. HAYES. The reason I ask, I want you to explain to this gentleman new people are very important.

Mr. ROE. That is why you were called upon——

Dr. FLETCHER. A lot of the people that are with me today are new people, but they have been with NASA and NASA programs before. So we look at them as new people with vast experience, and the hope that some of them are young with that experience.

Mr. HAYES. I have never heard anything I have had more support with in my entire life. I really want to ask you about the Space Station before my time is up. I am most interested in that.

Would you give me just your opinion as to the balance of science, the pure sciences in the station and whether we need to take a few additional steps in that direction, or whether you feel the balance is appropriate at the level now?

Dr. FLETCHER. Mr. Hayes, that is an awfully good question, and it is involved in this business of the revised estimate of the costs. Our configuration that we presented to this body last year really had a pretty good balance between a large number of aspects of space science. It had to do with physics, it had to do with earth observations, it had to do with microgravity, it had to do with the giant observatories, man-tended observatories. All of this was part of the Space Station program we presented last year. I am hopeful we can continue that. If we do, fully fund it, it will have the balance——

Mr. VOLKMER. Would the gentleman yield on that point? I would like to ask Dr. Fletcher something that concerns me a little bit, and that is, yes, you are trying to put science into the space station.

The next question is: For those projects that are scientific projects that are not to be included in the space station that would take a separate satellite, is it NASA's view that those should not be funded as much as those that would go on the space station? That is a concern I have. Are we pushing everything on the space station, in other words?

Dr. FLETCHER. Mr. Volkmer, I can't say we have done things exactly right, but all during the space station period, we plan to have a balanced NASA Space Program, and a balanced space program means that we have an appropriate amount of money in space science, and there are quite a few different subdisciplines in space science. So it is kind of hard to do the balancing act so all of them are adequately what they should be, but, yes, the overall NASA space science program will be a balanced program, some of it will be on the Space Station, some of it will not be.

Mr. VOLKMER. There is not going to be a preference, then, to a proponent of a project that goes on the space station as against one that would not?

Dr. FLETCHER. No, our intention is to put things on the Space Station that are natural for the Space Station. Things that are not natural, the best example of that, Mr. Volkmer, is that you don't put planetary missions on the Space Station, you put them on expendables, or in the early period on the Shuttle itself. It is not

planned that there be very many planetary programs on the Space Station. But there are many other examples.

Mr. VOLKMER. I thank the gentleman from Louisiana for yielding.

Mr. ROE. The chair recognizes the gentleman from Missouri, Mr. Buechner.

Mr. BUECHNER. I am interested in the prospect for medium launched vehicles and its prospect for commercial applications. Do you foresee any possibility of that use in the near future?

Dr. FLETCHER. I assume you are referring, Mr. Buechner, to the Air Force's Medium Launch Vehicle Program.

Mr. BUECHNER. That is correct.

Dr. FLETCHER. The fact it turns out to be a stretch delta is a happy thing for NASA, because as soon as that was announced we immediately transferred our studies to expendable launch vehicles to include the stretch delta, and I think it will play a very major role in our mixed fleet operations in years to come.

Mr. BUECHNER. I have been reading that France has basically been able to move into the gap that I think has been created by the shuttle going down in the area of launching satellites, and it looks like now that we are not going to be back into that competitive range for at least a couple of years.

Once that happens, do you think that they will have been able to dominate the market so severely that we won't be able to catch up?

Dr. FLETCHER. Mr. Buechner, that is a judgment question. Let me divide the answer into two parts. In the near term, the communications satellite companies particularly are going to take whatever they can get in the way of expendable launch vehicles. The Ariane is booked for, I don't know how many years out into the future. We have a few expendables left over. NASA owns some of them, and there are some the Air Force has.

They will use Ariane, Long March in China—some people have signed up for them. Russians are offering launch services for sale. In the near term, the customer will pay whatever the expendable launch vehicle requires. In the long term, there may be a shake out and the most cost effective expendable launch vehicle will be the one that wins out.

I hope there is more than one so we retain competition, but the long-term picture is less clear than the near term. The near term they will charge whatever the traffic will bear.

Mr. BUECHNER. What role is NASA playing in the President's SDI initiative?

Dr. FLETCHER. Only the role that we traditionally play, Mr. Buechner. We have always supported the Defense Department at NASA, and it was a service. They will use some of our organizational concepts. I mentioned the Technology Utilization Program earlier in my statement. They will take that and use that as a spin-off to help the commercial sector.

We cooperated with them on helping to set it up. We fly some of their missions when they are required, and I think generally cooperate as we would any other part of the Defense Department.

Mr. BUECHNER. Thank you very much. Thank you, Mr. Chairman.

Mr. ROE. The chair recognizes the distinguished gentleman from Missouri, Mr. Volkmer.

Mr. VOLKMER. Thank you very much. I would like to ask one more question in regard to science. What steps have you taken in the earth science such that NASA can support a vigorous international geosphere program?

Dr. FLETCHER. Mr. Volkmer, that is also a very good question. We think that is a high priority program, and it is a cooperative program with NASA and the National Science Foundation and NOAA. I guess we have decided to kind of be the leaders, but this is a three-way thing, and I know we have the international community excited and interested in it.

We have a number of programs that are part of that. We call it Earth System Science or some people say global climate and so forth. I would like to ask Dr. Burton Edelson, in charge of that program, to list some of the programs involved. There are a lot of programs now involved. We have some major future programs as part of that program. Burt?

Dr. EDELSON. I appreciate the opportunity to mention the programs. We have an extensive program, including the upper atmosphere research satellite, the TOPEX—ocean topography—satellite, which was approved in the 1987 program, the scatterometer, which is a radar instrument which will provide more information on oceanography.

In addition to that is the program of international solar terrestrial physics that Dr. Fletcher has already referred to in which we have two spacecraft in the proposal in the 1988 budget, all of which will contribute to NASA's program of earth science, which will allow us to be a leader. I should say the leader in the world earth system science effort, which is now being undertaken by the International Council of Scientific Unions.

Dr. FLETCHER. Just to add to what Burton Edelson said, part of the Space Station Program is oriented toward earth system science. The polar platform, which we sometimes call earth observation satellite, is a very basic part of the earth systems program, so the space station, itself, is contributing to the same program.

Am I off base?

Dr. EDELSON. You are exactly right. Thank you, sir. I would rather you say it that I.

Mr. VOLKMER. There is one additional question I would like to ask and that is—as I understand it, DOD has recently cancelled the remote ocean sensoring satellite. Would that satellite have been useful in this whole area of what we are looking into total, because as far as I know that is the only one that you would have caught that part of the earth.

Dr. EDELSON. Yes, the remote ocean sensing satellite was terminated by the Navy, and it was on that spacecraft we had intended to fly the scatterometer radar, which I just mentioned. However, the agreement with which that was being developed was an agreement not only with the Navy but also with the Air Force.

Now, the Air Force is taking on that responsibility, and we are in the process of working out arrangements with the Air Force to fly the scatterometer on one or the other of two of their spacecraft,

which will make substantially the same contribution to the Earth System Science Program.

Mr. VOLKMER. Thank you very much. Dr. Fletcher, to go to another area, from what I have read and heard on news reports, is the space station going to be a NASA-DOD space station, or is it going to be a NASA international cooperative space station?

Dr. FLETCHER. Mr. Volkmer, the answer is loud and clear. It is going to be an international Space Station. I feel good about that this morning, but a little uncertain about that yesterday, because we did settle out the concerns of the Defense Department at 11 o'clock last night, and I think we are going ahead and meeting with the——

Mr. VOLKMER. The February 11 meeting, as you said, is on and there is no question about in the future we are going to continue on with the international cooperative spirit and not going to let DOD put a cold pack on that?

Dr. FLETCHER. When you say, "No question," I think there is always a question. I think we have dealt with the problems of the moment and we are getting on with the negotiations with the Europeans. They, of course, have concerns, but I don't think we have changed anything in our basic agreement that should give them difficulty except possibly media coverage and things of that sort. We haven't changed our original intent in any way as a result of the Defense Department——

Mr. ROE. Would the gentleman yield? I think it would be profitable to explain to the committee your points of view vis-a-vis the cost of the Space Station. The press has been filled with different figures——

Mr. VOLKMER. And completion date.

Mr. ROE. People have established artificial prices for what the cost will be. I think that that just is not valid at this point at all. I think you ought to explain to us, the committee looks at the short-range policy goals to be a relationship between the orbiter, the new orbiter we are building, and the transportation system together with the space station.

We look to that to be a unity there from our point of view at the moment, and we notice there is a CBO report coming through that is going to call for reductions for funding both the shuttle and for the space station, which indeed would be a tragedy at this point. But I think it would be profitable for you to tell us, as you look at the short range issue, policy issue of the orbiters together with the space station, and the fluctuating costs, some people have talked about an $8 billion figure for the space station.

I think someone reported recently $13 billion. That is where we would like to get a little bit of observation at this point. I think that is important to us.

Dr. FLETCHER. Mr. Chairman, the questions you are raising are valid ones. I wouldn't say they are fluctuating costs. There are fluctuating newspaper accounts of costs.

Mr. ROE. That's the purpose of my question.

Dr. FLETCHER. We have not really estimated our costs well until the last two or three months. We had to wait, as you may recall, for the completion of the Phase B studies from the contractors to make an honest estimate of the cost. We are now taking those esti-

mates and adding to them our own evaluation of the elements of those estimates, and trying to come up with an honest cost estimate for the first time of our own.

We are in the process of trying to do that several different ways. We just haven't finished that study. I should quickly add we cannot go ahead with that program in terms of the development of the program until we have pinned down those costs, and I for one, am not going to do it.

Mr. ROE. No, no, I am not trying to put you in that position. I don't think you should be. I call to your attention we have to appear before the Budget Committee next week, and I would like to have—if the gentleman would yield further—I would like to have something to tell them.

There are some people that have in their mind this should cost no more than $8 million no matter what. I think that is ridiculous to begin with because you haven't nailed down what the facts are.

Where I am coming from, we need to get from you as quickly as possible what you see to be up front legitimately what the exposure of the United States costs would be to that program. I think that is important, because if we don't nail that down now that is all over the lot. Now, you have a meeting coming up as you indicated earlier with the international participants and so forth.

I would assume that that particular meeting would relate to what their participatory costs would be, and therefore you could nail down what our exposure would be from our budget point of view. But we need to be able to say to the Budget Committee that up front this is what we see to be the facts. This is what we think we need, and we need that next week. That is where I am coming from.

Dr. FLETCHER. I understand, Mr. Chairman. We will do our best. We have so many bases to touch we have to make sure——

Mr. ROE. I respect that.

Dr. FLETCHER [continuing]. OMB is satisfied with the numbers and so forth.

Mr. ROE. If the gentleman will yield further, it appears to me—maybe I am coming down too hard on you. We have to have figures, either we know what we are doing or we don't know. Somewhere between $8 and $13 billion is what we are talking about. I need to know from you or we are going to put the figure in one way or other or we are going to be fighting the administration on whether we build the space station at all.

This committee is concerned about that particular matter, and we need the answer.

Dr. FLETCHER. You are absolutely right.

Mr. ROE. If you guys don't put a figure on it, we will put a figure on it. We are going to build it one way or the other. The gentleman from Missouri——

Mr. VOLKMER. I believe my time has expired, Mr. Chairman.

Mr. STALLINGS. Thank you, Mr. Chairman. Dr. Fletcher, as you know, NASA had originally planned to release the RFPs for the next phase of the Space Program on February 3. That schedule has obviously slipped. Could you tell the committee, first of all, the cause of delay in the release of the RFPs and the steps that need to

be taken before they can be released and NASA's schedule for accomplishing these steps and releasing the RFP's?

Dr. FLETCHER. Yes, I think the chairman's observation on the costs is the only reason why those RFP's have slipped. We have a requirement from one of the committees of Congress, one of your subcommittees actually, and the Senate also, to not release those RFPs until we pin down the cost. We want to do that as quickly as possible.

We have our own thoughts about what the costs are. There is a little scatter in those. We are trying to reconcile that scatter. We also have got to get the approval of the Administration, and all of that. We are late, I have to admit that. Since we are late with the costs we are late in releasing the RFP's. I hope we can resolve that soon.

If next week is possible, we will do it by next week.

Mr. STALLINGS. Thank you, Mr. Chairman. No further questions.

Mr. ROE. I thank the gentleman. The gentleman from Virginia, Mr. Slaughter.

Mr. SLAUGHTER. No questions.

Mr. ROE. No questions? Mr. Lewis from Florida.

Mr. LEWIS. Thank you, Mr. Chairman. Good morning, Dr. Fletcher. I am concerned about the perception in Congress the DOD is basically being asked to fund the lion's share of the areospace plane, and there is different sets of numbers that are being moved around.

Last year's appropriations was like $45 million from NASA, $120 million from DOD. Isn't it true that with your R&T, and also the facilities manpower costs that you are including a lot more funding into the aerospace plane than is being indicated?

Dr. FLETCHER. Mr. Lewis, of course we have to be accurate in our numbers. The numbers that we display precisely are the numbers which are in the R&D budget. That is a fraction of the total cost. The lion's share will be the Defense Department, but in the early phases, of course, it is a multi research and technology. We contributed in our early phases more than our ultimate share.

What you have observed is true. We have as part of our R&PM budget, I don't know how you calculate it in dollars, additional effort. This a people problem and facilities problem. All of that is in addition to the R&D budget that was displayed. I don't know whether we have an estimate of the overall contribution. This is R&D plus people—do we, Tommy? It is larger, as you properly pointed out, than the R&D estimate.

Mr. LEWIS. Is there any way you could provide the committee with a true comparison?

Dr. FLETCHER. I think we could provide that for the record.

[The material referred to follows:]

Identified below is the National Aero-Space Plane (NASP) program funding commitment of both NASA and DOD for FY 1987 and FY 1988:

| | 1987 | | | 1988 | | |
|---|---|---|---|---|---|---|
| | NASA | DOD | Total | NASA | DOD | Total |
| NASP funding commitment | 62 | 110 | 172 | 84 | 241 | 325 |
| Transatmospheric R&T | (45) | ..... | ..... | (66) | ..... | ..... |
| R&T Base (Aero/Space) | (17) | ..... | ..... | (18) | ..... | ..... |

In addition to the above R&D funding contributions, NASA has 320 civil service workyears supporting the NASP program out of the R&PM appropriation. This equates to approximately $24 million in FY 1987. Also, the NASP program is being supported on a priority basis at the NASA Research Centers by high-speed wind tunnels, simulators, and other national aeronautical facilities where required. This includes significant dedicated support by the Numerical Aerodynamic Simulation computer capability at Ames Research Center and by other Class VI computers at both Langley and Lewis Research Centers. In addition to the civil service salaries mentioned above, the estimated facility support is $45 million in FY 1987. The total NASA contribution is estimated to be $131 million in FY 1987.

Mr. LEWIS. Each agency of the program?

Dr. FLETCHER. We have it in terms of people. You have to add people to dollars. We have to translate that.

Mr. NEWMAN. There are about 300 civil service on the program, and you are right there it is about 17 million in the research and technology base, in addition to the 45 million in the research and development activity.

Mr. LEWIS. I think our subcommittee in particular on transportation and aviation would like to have those numbers, comparison numbers, if we could have them, Dr. Fletcher.

Dr. FLETCHER. I am sure we can provide those, Mr. Lewis.

Mr. LEWIS. Also, Mr. Lujan alluded to it. There is considerable concern, and I have been receiving a tremendous amount of mail for the observatory flight. I don't know what the interest is out there. I thought most of the interest was in getting the February 18 shuttle launch next year and also moving on the space station.

All of a sudden Mars is becoming a real star—that is not a pun—in our programming. I am just wondering if you have any reasons why this is becoming so popular.

Dr. FLETCHER. Mr. Lewis, we may have generated our own problems in that regard. What we did was schedule four planetary missions in three planetary slots on the shuttle. We had the mission of Magellan, Ulysses, Galileo and Mars Observer all planned for three slots in the 1989-90 period.

Well, obviously we couldn't do that, and so we left open the possibility of putting one or the other of them on an expendable launch vehicle, and we now have a plan to do that but we don't have the expendable launch vehicle. But the normal way of doing it would be to schedule three planetary missions for those three slots and put the Mars Observer out in the 1992 period, and we did schedule it that way on the Shuttle.

We reserved the option of putting one or the other of those on any expendable launch vehicle, and the Mars Observer is clearly the leading candidate apparently from all the mail and the pressure for that launch on an expendable launch vehicle. I think that is the reason for the pressure.

Mr. ROE. Will the gentleman yield?

Mr. LEWIS. Certainly.

Mr. ROE. In view of that statement, we are puzzled as to why you didn't request any funding for expendable launch vehicles.

Dr. FLETCHER. Mr. Chairman, that is a good question, but the main reason is we didn't have all our facts together. It is not a trivial problem. It is not just slipshod work on our part, but, the only way we can get an expendable launch vehicle that fits the Mars Observer is to beg, borrow—I don't want to say steal.

Mr. ROE. We may have to do that.

Dr. FLETCHER. Beg and borrow from the Defense Department. Those negotiations are difficult.

Mr. ROE. Wait. Wait. Wait. If the gentleman would yield further, it is the committee's desire and intent to get this show on the road and get on with it. We also recognize your constraints.

Let me ask it differently. If Congress were to provide you with the funding, which you didn't ask for, for the expendable launch vehicle, would it speed up your program?

Dr. FLETCHER. It certainly would speed up the program because a lot of the negotiations with the Defense Department have to do with price. If we had the additional money, we could negotiate from strength.

Mr. ROE. You are almost as diplomatic as I am. I want to get on the record, if the gentleman will yield further, I will give you additional time, of course. We are paying $6 million a month to maintain this equipment, and it seems to me, I can count, and we have got to be able to say to our brothers and sisters who are going to have to make this decision whether we provide the funding.

What do you need to speed up the program, and maybe you can't speak to that, but I want to get it on the record. We see that to be an extremely important issue, and whether we have to negotiate with DOD or whomever we have to negotiate with, the issue is if we were to provide you funding for additional expendable launch vehicles, would it accelerate your program, and would we be able to move ahead faster? With safety, of course.

Dr. FLETCHER. Mr. Chairman, I think in all fairness Admiral Truly and Mr. Myers have been negotiating intensely with the Air Force on this, and I would tell Myers to at least start an appropriate response to that. It is not a trivial thing, as Dale will clarify.

Mr. MYERS. We have had a whole series of reviews of the opportunities that would be available to us to accelerate some of the planetary missions. The particular one we have emphasized, because of the strong interest of the science community is the Mars Observer acceleration in 1990, the TDRS that we mentioned earlier as being a very critical one that should go as quickly as we can go with, and a whole series beyond that that are critical, important science missions and could be taken off the Shuttle and used on an expendable launch vehicle.

The issue that comes up is that most of those devices are relatively heavy, and they do not naturally fit on the smaller delta rockets. They require the Titan III's or possibly even the Titan IV that is being developed, because the Shuttle really has a very large payload capacity, capability and the expendable launch vehicles, only the very largest ones fit those missions that had been designed originally for the Shuttle.

Where we stand today, is that the Mars Observer could go on a Titan III very nicely in that 1990 window. The problem is that—by the way, TDRS would go on a Titan III. So we have been working at the problem of where do we stand with the Air Force on the pricing and the availability of those vehicles in that time period.

We believe there are Titan III's that can be made available for the window of the Mars Observer and for an early launch of the TDRS. We have worked out through a lot of really good negotiations, I think, with the Air Force, a new pricing policy for how we would pay for each other's launches, and that has resulted in a hand shake that I have had with the Secretary of the Air Force, Mr. Aldridge, which gives an advantage in the quid pro quo arrangements between NASA for our launches and the Air Force for their launches, and I think an arrangement that gives us better assured capability of having alternate launch availability for us.

All this is boiling down to our position on an important additional launch capability for NASA's early requirements that we almost have tied up in pricing arrangements for the Air Force, and in our position as to what we believe ought to be done. And the final bottom line is additional funding in 1987 and 1988 would clearly help in TDRS launches and Mars Observer.

Mr. ROE. Whether it comes through NASA or DOD? In other words, if you are putting—if you are putting together an arrangement, I don't want to get into it, because it is not necessary we discuss it now. The question I want to ask is additional funding wherever it comes that would accelerate that program would be helpful?

Is that succinctly enough?

Mr. MYERS. Very succinctly. It would be better in NASA's budget.

Mr. ROE. I hope so, unless we are going to turn it over to DOD.

The gentleman from Florida.

Mr. LEWIS. Dr. Fletcher, with the recent anniversary of the Challenger, once again we are reminded of the tremendous negative impact this disaster had on our nation's school children. As you may recall in our discussions, I discussed it with the President, this committee did unanimously concur with my amendment to H.R. 5495 in last year's NASA authorization bill to allow the elementary school children to enter into a contest to name the next Shuttle.

The bill was vetoed, and apparently for other reasons, and I would like to know how we are proceeding on this at this point in time.

Dr. FLETCHER. I think your bill was very much in order, and I don't know in detail the reason for proceeding, but it seems like a good idea, and I think we have taken it under advisement. We may proceed that way without the bill. Admiral Truly is involved in that exercise. He may want to respond as to where we stand in this regard.

Admiral TRULY. Mr. Lewis, it has been some weeks since I have discussed this. When Rick Hauck was up at Headquarters as Associate Administrator for External Affairs, he took over the lead in that very project to have an appropriate way to get suggested names from school children into a system that would be considered so that we could name the orbiter.

As you know, one of the happiest parts of the shuttle recovery was when we got far enough along we could name a crew, and Rick is commander of the crew and has now returned to Houston for training. But I believe that proposal, despite the veto of the bill, is in the works.

Mr. LEWIS. I would like to check with you further on that, Admiral, next week.

Mr. ROE. I thank the gentleman from Florida. The chair recognizes the gentleman from Florida, Mr. MacKay.

Mr. MACKAY. Thank you.

Dr. Fletcher, we are now at the end of an agonizing year in which you and your staff have been doing an excellent job of reviewing our program to strengthen it to make sure we don't make the same or fall into the same problems we have again as we have in the past. I gather from press accounts, one conclusion of the review thus far is we shouldn't have allowed ourselves to get into a situation where there are no other options than the shuttle to keep your program going, and, in fact, a lot of our discussion this morning is talking about how are you going to work your way out of this box that we are in?

I would like to focus on the bottleneck problem. It seems to me long term your ultimate bottleneck—once again, this comes from reading press accounts—is that top-quality young scientists are concluding there are going to be such delays that this is not a desirable place for a research career. Many of these pressures that are coming for like the Mars observer and other programs are not just popular pressures, they reflect very serious concern if we don't keep this thing going, delay is going to be such it is not going to—in a man's lifetime is not going to get to see the results of his work.

You, in fact, are at the peak of a huge civilian scientific community, and what we are talking about is people's careers, and we are going back to a more fundamental question, whether this program is going to continue to attract people.

What I am asking is: In terms of putting one project ahead of another, where does the question of NASA's long-range ability to continue to attract its ultimate research, which is the brightest scientific minds, where does that come in as compared to whether we have got a space station and whether we cooperate with the Russians?

I respect you very much. The one answer you have given, I think is totally nonsense, is we have to do something faster because the Russians might get to Mars two years ahead of us. What in the world do we care?

Dr. FLETCHER. I hope I didn't say it that way, Mr. MacKay.

Mr. MACKAY. I thought I heard that.

Dr. FLETCHER. We regard space science just as awfully important. This country is second to none in terms of our activities in space science. I think it will continue to be so.

But the question you raise, which I think is very cogent, is what about the young people that are trying to decide what careers to follow because the space science programs have been slipped anywhere from two to five years downstream? The Galileo was the worst example I know of. We won't be getting to Jupiter with the Galileo program until sometime in the mid 1990s, and that pro-

gram started when I was still in NASA nine years ago. This is a bad situation.

We are doing two things. We are not going to solve the problem, because there is just too many variables. We are going to try to alleviate it the best we can. We are doing two major things, and maybe several others ought to be mentioned. We are trying to devise some expendables so we can get some of those missions moved up. We had discussion about the Mars Observer being one of them. There are needs for other expendables to work out the science backlog in the 1990 to 1995 period. I think we have already started some of that, but we didn't have enough money in the fiscal year 1988 budget for buying the appropriate expendables, but we did buy a Delta launch vehicle, and we are launching COBE, as we call it, Cosmic Background Explorer, only six months from when it was scheduled. That is only one example. We are trying to buy expendables to move those figures earlier, sooner. We will be coming back to you with an appropriate complete expendable program, but the focus will be on the requirements in the fiscal year 1987 and 1988 period.

Mr. MACKAY. But your increased expenditures, as reflected in your budget requests this year, are not for that, they are for the space station, and I think you can make a pretty good case in terms of civilian pure science, the state of the art has to do with the programs that are getting pushed back, not the space station.

Dr. FLETCHER. In addition to that, the second point I was going to make, Mr. MacKay, is that we in the fiscal year 1987 actually put something like $20 million in what we call a vitality package. It is augmented in the fiscal year 1988 budget to take care of just the question that you mentioned: the young scientists that want to do research but can't spend the time waiting five years for a mission. This money will be spent on scientific missions which are right in front of us that can be done with suborbital, we call it suborbital, those are research rockets, balloons, we have an augmented balloon program and also a program designed to—I should say we have the Kuiper aircraft and other aircraft which have scientific missions on them augmenting all those programs. In addition, reducing the data we have already got from space, from the planets, from the other observatories and making that available and money available to translate that data into important scientific discoveries.

Now, that's what we have done. You can't just automatically add dollars and get these people back on track. You have to add dollars to support the young scientists, and then you have to move the missions up as early as possible.

The only place where I think we are lacking is, we weren't able to finish our negotiations for early launches, which we have to get from the Defense Department. There is no other way to get those vehicles except from the Defense Department.

Mr. MACKAY. Mr. Chairman, I would like to pursue this. My time has expired. If time allows later, I will try to come back to it.

Mr. ROE. If you have——

Mr. MACKAY. I have only one question. This is a hearing where we ought to be talking about where are we heading? And here we have press accounts that say NASA is in disarray, policy disarray.

It is okay to say the press is irresponsibly reporting it. That is coming from people in the scientific community who say we think that our aspirations exceed the reality of the problem we are in.

And I might say, my own personal impression is that the person who was on this committee and trying to raise questions about the flight frequency and so forth, we are in danger of getting in the same box that got us in this problem we are in now, and that is we tried to do too much. We pushed the program too hard. Something went wrong, and it turned out we had no other options. If we get back into this, isn't that going to push these pure science experiments off the timeframe again?

In other words, shouldn't this committee be asking you, the space station is all right, but it is so huge, isn't it going to tend to preempt everything else? I guess that is the question I am asking.

Dr. FLETCHER. I think that is a fair question and the answer is no. We have kept the space science budget over the years approximately 20 percent of the total R&D budget, and we plan to continue the same. Unfortunately, we are at a hiatus period because you might say because we should have ordered expendable launch vehicles way back and had a mixed fleet way earlier. We have a mixed fleet concept now, we are going to address very soon the question of what we can do in this down period, this five-year period, what kind of expendable launch vehicles might be available?

If you extend it out beyond five years, you have all these medium launch vehicles from the Air Force that will be available, but the near-term is the thing we have to focus on. We want to buy whatever expendable launch vehicles are available, and we plan to do that and come to you soon with a program to show what is the best way to do that.

Mr. Myers has already explained two such urgent requirements, one is the Mars Observer, and the other is TDRS, which is not space science, but nonetheless urgently required for our program. We will have a broader program—it is under study. We will have the whole program hopefully in this spring sometime. But the early part is almost finished.

Mr. ROE. Will the gentleman yield?

What we are trying to get at, Doctor, is because of the Gramm-Rudman legislation, the timeframe has been put back one month for us to complete our recommendations in the Budget Committee—and, therefore, the Congress—as to what we need. I think what the gentleman is simply saying: Are we bold enough? We need to move now. I, for one, along with the other members of this committee, are very much concerned about the manifest and where we are going. In order for us to present a substantive position to the Budget Committee, we have to reflect upon what your observations are, so we do have a timeframe involved.

Now, if the gentleman will yield further, from my point of view, we recognize there are extraordinary problems, and we recognize caution, but now we have a report coming out from the Congressional Budget Office that says maybe we are going to balance the budget or cut those costs, we should cut out the shuttle, we should cut out the space station. We are going to have to justify what you feel your folks can achieve and do.

Now the question is, are we bold enough in what you are saying today to achieve that goal? I have to justify this, along with these other members of this committee, to the Budget Committee. I am concerned not only at what the future is going to be but whether we can hang onto what we have and time is the enemy at this point.

Dr. FLETCHER. Mr. Chairman, you are absolutely right, and we are late in getting those numbers to you. There are several threats to the fiscal year 1988 budget. One is the expendable launch vehicle program that we just discussed. The other is the possible cost, revised estimates on the Space Station. We have to deal with that.

We also have another one which we haven't discussed yet, and that is we feel we ought to be thinking about the long-term, the future of NASA, what is the program likely to be that follows the Space Station, further missions out into space. We haven't addressed that problem yet. These are all threats to the fiscal year 1988 budget.

I don't know that we have the option to plug numbers in for those things. We would have to come up with the best estimate that we can, and we have just not finished those estimates yet.

Mr. ROE. When will the estimates be finished?

Dr. FLETCHER. Each one is in a different category. We will have the estimate of the threat due to ELVs shortly. As soon as we can get it through our friends at OMB.

Mr. ROE. Are we talking a month or six weeks or two years? What are we talking about?

Mr. MYERS. I think we will have our act together within three weeks.

Mr. ROE. OK.

Mr. MYERS. I think that probably some time has to be added to that to go through OMB before we can come to the Congress.

Mr. ROE. I understand that. All right.

The gentleman from Florida.

Mr. MACKAY. Thank you. I don't have any further questions.

Mr. ROE. The chair recognizes the distinguished gentleman from Indiana, Mr. Hamilton.

Mr. HAMILTON. Thank you very much, Mr. Chairman.

Dr. Fletcher, can you assure us that the next shuttle will be a significantly safer vehicle?

Dr. FLETCHER. Well, if it isn't, it will be over my dead body. That is our whole goal. It is going to be considerably—I don't want to say marginally—it is going to be considerably safer before the accident. If we haven't learned anything from the accident, we are not doing our job.

Mr. HAMILTON. Can you spell that out for us in more detail?

Dr. FLETCHER. Yes, indeed. In addition to fixing the cause of the accident, which were the seals, the field joints, as we call them, in the solid rocket motor, there were problem throughout the Space Shuttle that were, I would say, anomalies. Some people would say dangers, whatever the case was. We have a long list of those mandatory changes to the shuttle system. The last I heard was 100, but I have heard much higher numbers lately. They are all going to be implemented in the next flight, and some of them farther downstream.

Nonetheless, all of these changes are designed to make the Shuttle much safer and much more reliable. We can enumerate some of those highlights, for example, we are going to fix the landing gear on the orbiter, we are going to fix—the nozzle had some problems with it on the solid rocket motor. Those are being greatly improved.

We had a problem with the nose steering wheel, and that is going to be dealt with. You could go on, but the list is 100 some odd. We could provide a list for the record. It is going to be a much safer, much more reliable vehicle.

[The information follows:]

The following is a listing of the Space Shuttle mandatory changes presently planned for incorporation prior to first flight.

# MANDATORY ORBITER HARDWARE MODIFICATIONS PRIOR TO FIRST FLIGHT

1. 17-INCH DISCONNECT
2. RCS BURNTHROUGH DETECTION
3. APU ISOATION VALVE
4. APU DRAINLINE HEATER
5. APU FUEL LINE TEMPERATURE
6. BRAKE MODS-STIFF AXLE, ORIFICE/THICK STATORS, BALANCED PRESSURE, ANTI-SKID BLOWN TIRE
7. TIRE PRESSURE MONITORING
8. AC BUS FUSE PROTECTION
9. MDM RECHANNELIZATION
10. AFT WIRE PROTECTION
11. FUEL CELL NO. 3 GROUND
12. FUEL CELL WATER REMOVAL
13. P-V ANTI-SLAM PNEUMATIC FILTERS
14. AC MOTOR CONTROL VALVE
15. IMPROVED CCTV MOUNTS
16. MLG BUNGEE RIGGING
17. TPS WING / ELEVON COVE REDESIGN
18. UMBILICAL HOLD DOWN SPHERICAL WASHER
19. UMBILICAL HOLD DOWN PINCHED WIRE
20. AFT ATTACHED PINCHED WIRE
21. EMERGENCY EGRESS SLIDE
22. WASTE MANAGEMENT WIRING
23. FLASH EVAPORATOR SYSTEM COVER
24. SSME HYDR QUICK DISCONNECT
25. ENGINE INTERFACE UNIT POWER
26. $H_20$ TANK PRESSURE LOSS
27. BF & R/SB POSITION TRANSDUCER
28. DUMP RECHANNELIZATION
29. ET DOOR UMBILICAL TORQUE LIMITER
30. PANEL F9 FUSE

# SSME MANDATORY CHANGES
## PRIOR TO FIRST FLIGHT

1. HIGH PRESSURE FUEL PUMP - INCORPORATE PHASE II MODS
2. HIGH PRESSURE OXIDIZER PUMP - INCORPORATE PHASE II MODS
3. NICKEL PLATE MCC OUTLET NECK
4. INCORPORATE HYDRAULIC ACTUATOR CLEANING AND COIL REDESIGN
5. INCORPORATE CHANGES TO REDUCE HPFTP COOLANT LINER PRESSURE
   - INCREASE COOLANT SYSTEM VENT AREA
   - INCORPORATE STATIC SEALS
6. REWORK MAIN INJECTOR LOX INLET MANIFOLD SEAM WELD
7. MAIN COMBUSTION CHAMBER BURST DIAPHRAM VENT DRAIN LINE
8. MODIFY HIGH PRESSURE FUEL DUCT FLANGES AND REDUCE PRELOAD TO PREVENT LEAKAGE
9. INCREASE HELIUM PURGE FREQUENCY DOWNSTREAM OF MAIN FUEL VALVE TO PREVENT ICE BUILDUP DURING PRELAUNCH
10. ADD REDUNDANT SKIN TEMPERATURE SENSORS TO ANTIFLOOD VALVE
11. INSTALL REPLACEMENT DELAY LINES, LADDER SWITCH AND DIODE BLOCKS
12. REPLACE FASCOS HYBRID CIRCUITS TO PREVENT ERRONEOUS ENGINE SHUTDOWN
13. REVISE SOFTWARE BASELINE TO INCORPORATE UCR FIXES AND REQUIREMENTS CHANGES
14. HIGH PRESSURE FUEL TURBOPUMP FIRST STAGE BLADE FIRTREE LOBE CRACKS
    - SHOT PEEN, MODIFIED FIT, AND REDUCED POROSITY ACCEPTABILITY
    - HIT FIRE SCREEN EXISITNG BLADES

# SSME MANDATORY CHANGES
## PRIOR TO FIRST FLIGHT (CONTINUED)

15. HIGH PRESSURE FUEL TURBOPUMP SECOND STAGE BLADE FACE CRACK
    - SHOT PEEN, GOLD PLATE FACE AND REDUCED POROSITY ACCEPTABILITY
    - SHOT PEEN, THERMAL COATING AND REDUCED POROSITY ACCEPTABILITY

16. HIGH PRESSURE OXIDIZER TURBOPUMP FIRST STAGE BLADE SHANK CRACKS
    - INCORPORATE TWO-PIECE DAMPER
    - SHOT PEEN
    - USE EXISTING BLADE DESIGN WITH ONE FLIGHT LIMIT

17. HIGH PRESSURE OXIDIZER TURBOPUMP BEARING DISCOLORATION
    - DEMONSTRATE ACCEPTABILITY AT 104% BY HOT FIRE EXPOSURE
    - USE EXISTING DESIGN FOR ONE OR TWO FLIGHTS

18. LOW PRESSURE OXIDIZER TURBOPUMP BEARING DISCOLORATION
    - ELONGATED CAGE POCKETS, ION IMPLANTATION
    - DEMONSTRATE ACCEPTABILITY OF EXISTING CONFIGURATION

19. IMPROVE RELIABILITY OF HOT GAS TEMPERATURE SENSOR
    - MODIFY MANUFACTURING PROCESSES TO PREVENT INTERNAL MOISTURE
    - ADD THIRD SENSOR AND MODIFY SOFTWARE

20. DEGRADATION OF HELIUM PURGE CHECK VALVE DURING MAINSTAGE
    - ASSESS ACCEPTABILITY OF CURRENT CONFIGURATION
    - IDENTIFY POTENTIAL ALTERNATE SOLUTIONS

SRB MANDATORY CHANGES
PRIOR TO FIRST FLIGHT

1. TVC HYDRAULIC BLEED VALVE REPLACEMENT
2. TVC QUICK DISCONNECT POSITIVE LOCK
3. TVC MAGNETIC PICKUP UNITS MALFUNCTIONS
4. FWD/AFT IEA MODIFICATIONS
5. DEVELOPMENT FLIGHT INSTRUMENTATION SYSTEM
6. ETA RING, NEGATIVE MARGINS OF SAFETY
7. MLP/SRB SEPARATION SYSTEM DEBRIS CONTAINMENT
8. SRB SYSTEMS TUNNEL
9. CASE FIELD JOINTS
10. CASE FACTORY JOINTS
11. NOZZLE-TO-CASE JOINT
12. NOZZLE
13. SYSTEMS TUNNEL
14. IGNITER
15. PROPELLANT

MANDATORY FLIGHT SOFTWARE MODIFICATIONS
PRIOR TO FIRST FLIGHT

1. 17-INCH DISCONNECT LATCH SEQUENCING
2. TURBINE DISCHARGE TEMP SENSOR REDUNDANCY REDESIGN
3. RCS TANK PRESSURE D/L SAMPLE RATE INCREASE
4. RCS REGULATOR FAILURE PROTECTION
5. NO YAW JET FCS MOD
6. NO YAW JET FCS MOD IN BFS
7. RCS CROSSFEED MCA OPTIMIZATION
8. GRTLS ET SEP RCS JET SPF PROTECTION
9. WOWLON ROLLOUT SET PREMATURE FIX
10. SRB RGA RECHANNELIZATION
11. MDM A/D CONVERTER FAIL DETECTION
12. SRB SEP SEQ MOD FOR MDM FAIL FIX
13. MPS DUMP/STOW CONCERNS
14. APU ISOL VALVE REDUNDANCY REDESIGN
15. UNCOMMANDED BRAKE PRESSURE INSTRUMENTATION/FDA
16. MANUAL NWS FCS UPDATE
17. LOAD RELIEF MOD
18. TIRE PRESSURE MONITOR CAPABILITY
19. INADVERTENT MODE TRANSITION PROTECTION
20. BFS CLEANUP FOR INADVERTENT MODE TRANSITION

MANDATORY FLIGHT SOFTWARE MODIFICATIONS
PRIOR TO FIRST FLIGHT (CONTINUED)

21. OMS DUMP WITH 3 SSME'S FAILED IN MM102 (SPLIT-S)
22. GRTLS DAP MOD FOR SPLIT-S RTLS
23. AUTOLOFT, FIRST STAGE CONTINGENCY
24. OMS XFEED PRESS DISPLAY & D/L
25. CABIN SMOKE DETECTOR RESET SWITCH FDA
26. PAD DATA PATH FAIL CRITERIA
27. PAD ABORT He INTERCONNECT
28. SSME ERRONEOUS SHUTDOWN CONTROL LOGIC CONCERNS
29. APU FAILED DAP MODING
30. VENT DOOR BFS ENGAGE PROBLEM
31. NZ LIMIT FOR MM304 OMS DUMP
32. CENTAUR MISSION CONSTRAINT
33. RCS MANIFOLD DILEMMA UPDATE
34. CORRECT ORBITER RGA/AA AND SRGA FDI
35. LISTEN MODE RCS DUMP COUNTER
36. DUMP ITEM DISPLAY CLEANUP
37. CENTAUR REQUIREMENTS DELETION
38. DELETION OF HUD FORMAT 2
39. DELETE UNUSED FCS DOWNMODING
40. CHECKSUM SOP SCRUB
41. CODE OPTIMIZATION (OMS/RCS XFEED; RCS QUANTITY MONITOR)
42. VENT DOOR SEQUENCE SCRUB
43. VENT DOOR CODE OPTIMIZATION SCRUB
44. FLIGHT CONTROL SYSTEM DOWNLIST SCRUB

MANDATORY GROUND SYSTEM
RETURN TO FLIGHT MODIFICATIONS

1. EMERGENCY EGRESS SYSTEM - ADD TEMPERATURE MEASUREMENTS AND FIRE DETECTION
2. HYPERGOLIC FUEL VAPOR DETECTORS - ELECTRO CHEMICAL CELLS REDESIGN
3. HYPERGOLIC FUEL VAPOR DETECTORS - PORTABLE HVDS UPGRADE
4. O2 ANALYZERS COMPLETE SYSTEM AND ELIMINATE INACCURACIES AND INSTALL PCR O2 ANALYZERS
5. HAZARDOUS GAS DETECTION SYSTEM (BACKUP) - AND MASS FLOW METERS
6. HAZARDOUS GAS DETECTION SYSTEM - ELIMINATE VALVE FAULT PROBLEM
7. PIC SYSTEM - KEY CONNECTORS AND SEPARATE PRIMARY AND REDUNDANT CABLING
8. METEOROLOGICAL SYSTEM - UPGRADE
9. RSS DRIVE TRUCKS - CHANGE BEARINGS
10. RSS - DEVELOP WEIGHT VERSUS CLEARANCE MATRIX AND PARKING PLAN - RSS OMRSD CHANGE
11. LAUNCH COMPLEX - HARDEN TO PRECLUDE DEBRIS
12. PAD/MLP - PERFORM TEMPERATURE ANALYSIS
13. PRSD DISCONNECT CENTERING DEVICE
14. HOLD-DOWN POSTS - REDESIGN KICKER SPRINGS
15. TAIL SERVICE MAST - ELIMINATE GALLING
16. EMERGENCY EGRESS SYSTEM - UPGRADE FOR BETTER CREW PROTECTION

MANDATORY GROUND SYSTEM
RETURN TO FLIGHT MODIFICATIONS

17. PAD WATER SYSTEMS - FREEZE-PROOF
18. MATE/DEMATE DEVICE - STRESS ANALYSIS
19. $H_2$ VENT FLARE STACK - ELIMINATE HAZARD
20. MPS LOX/$LH_2$ SYSTEM - INSTALL DEBRIS TRAP
    INCORPORATE LEAK PROOF JOINT
21. PAYLOAD CHANGEOUT ROOM - ECS UPGRADE
22. EXTENDABLE PLANK DRIVE SYSTEM
23. LRU PLATFORM - PIN EXTENDABLE PLATFORMS
    - SQUARE TUBE DESIGN SPEC.
24. MAN-RATE ET ACCESS PLATFORMS
25. ET CHECKOUT CELL - BEEF UP RESTRAINTS
26. ET $GH_2$ VENT SYSTEM REDESIGN TO PRECLUDE VEHICLE INTERFERENCE
27. DESIGN OF GSE/UMBILICAL SYSTEM FOR SRB JOINT
28. ELECTRICAL GSE DESIGN FOR SRB JOINT HEATER
29. 8 INCH QD $LH_2$ LEAK DETECTION SYSTEM
30. VAB HIGH BAY 3 VEHICLE CLEARANCE ANALYSIS
31. PREVENT INADVERTENT ACTUATION OF PCR DELUGE SYSTEM
32. REMOVE P/L PURGE SYSTEMS FROM PAD B BREATHING AIR SYSTEM
33. ELIMINATE PCR MAIN DOOR JERKY MOTION
34. REMOVE TEMPERATURE PROBE FROM MPS LOX PUMP SUCTION
35. CORRECT PGHM LURCHING MOTION

Mr. HAMILTON. As a result of that tragedy, would you say that we will examine much more carefully whether or not a given expedition will be manned or unmanned than we might have before the accident? In other words, will you weigh that question more carefully?

Dr. FLETCHER. Well, I interpret your question to mean whether the mission will be put on expendable launch vehicle or a Shuttle. Yes, indeed. Those that are more natural to the Shuttle will be the ones that will be emphasized, As those will be things like giant observatories, things like the Space Shuttle that require a large cargo bay.

There will also be programs that are sort of unique that need people to tend the experiments. A Spacelab would be a good example of those. Things like planetary, they are not so natural to the Shuttle. We will try to move those onto expendable launch vehicles.

Mr. HAMILTON. To pick up on one of the earlier questions, let me ask you about your long-range civilian space goals. If you were to identify for us the goals in the civilian space program, say 10 years down the road, what would you say they would be?

Dr. FLETCHER. That is a very good question, because we are just in the middle of a self-examination so to speak, and we have set for ourselves—by the way, Mr. Chairman, I will supply that for the record, some internal goals of what NASA's mission ought to be. What is our vision of the future, what are the goals that we ought to be pursuing. I can kind of rattle off some from the top of my head, but we can supply you for the record our internal memo.

[The information follows:]

The following is an agency memorandum of NASA's visions and goals.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

December 9, 1986

TO: All NASA Employees

FROM: A/Administrator

SUBJECT: NASA's Vision and Goals Statement

NASA has recently embarked on an effort to define the goals, objectives, and program thrusts to guide the future of the Nation's civil space program. It is our intent that this process produce a blueprint to guide the United States to a position of leadership among the spacefaring nations of Earth.

The process will necessarily be lengthy, as it must be both thorough and creative. The first steps were taken at the NASA Senior Management's Strategic Planning Council meeting in October when the agency's broad goals were revised. The results of that effort are enclosed. The next steps will be to define the more specific objectives which fall under the goals, then to identify the program thrusts required to achieve our goals and objectives.

NASA embodies the human spirit's desire to discover, to explore, and to understand. Our overarching goals are to achieve advances in aeronautics, in space science, and in the exploration of the solar system.

In aeronautics, breakthroughs in high-speed flight and emerging technologies in high-strength materials, automation, and controls will reshape civilian and military aviation in the next century.

The Hubble Space Telescope, the Galileo probe of Jupiter, the Ulysses observation of the Sun's poles, and the Earth orbiting polar platforms to study our home planet are examples of missions in pursuit of our science goals.

The Space Station will establish a permanent human presence beyond the surface of the Earth. Thus, the Space Station is a vital step in our building process. As this zero-gravity laboratory evolves, it will serve as a point of departure for future missions of exploration.

In order to achieve our goals, we must develop world-class facilities, advance technologies, and improve our transportation capabilities. Returning the Space Shuttle to flight status is a crucial step in resuming the United States' activities in space.

In addition to this highest priority effort, NASA will continue to develop both cargo and passenger vehicles to assure American launch capability. Advancing research in science and technology in areas such as robotics, automation, advanced propulsion, and microgravity physics is critical to NASA leadership in space, as well as to future private sector initiatives.

Underlying each of these goals is the need to develop and nurture the human resources capable of meeting the challenges and adventures of our future endeavors.

In the months ahead, we will be reviewing and developing the more specific objectives associated with the broad NASA goals, then the program thrusts which will carry us toward those objectives. We intend to involve representatives from all levels of NASA as we proceed with this activity.

I look forward to reporting on our progress in the coming months.

James C. Fletcher

Enclosure

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## MEETING THE CHALLENGE IN AERONAUTICS AND SPACE

### NASA GOALS

NASA's vision is to be at the forefront of advancements in aeronautics, space science, and exploration. To set our course into the 21st Century and bring this vision to reality, NASA will pursue major goals which represent its aspirations in aviation and space. These goals are:

- **Advance scientific knowledge of the planet Earth, the solar system, and the universe beyond.**
- **Expand human presence beyond the Earth into the solar system.**
- **Strengthen aeronautics research and develop technology toward promoting U.S. leadership in civil and military aviation.**

Successful pursuit of these major goals requires commitment to the following supporting goals:

- Return the Space Shuttle to flight status and develop advanced space transportation capabilities.
- Develop facilities and pursue science and technology needed for the Nation's space program.

As NASA pursues these goals, we will:

- Promote domestic application of aerospace technologies to improve the quality of life on Earth and to extend human enterprise beyond Earth.
- Conduct cooperative activities with other countries when such cooperation is consistent with our national space goals.

December 1986

Dr. FLETCHER. Basically we want to continue to be, retain our excellence in aeronautics technology. We are second to none in the world in that arena. We also want to retain our excellence in space science. Again, I think we are second to none in that arena although we have some slips. We are not going to let that bother us, we are still going to be first in the world.

We also feel it is important that we have people in space, permanent humans in space, and the Space Station is an example of that. But we also feel that we ought to extend out farther into space the occupation of people, particularly Americans in space, and just what the next step will be in that arena we are right in the middle of a number of studies to determine.

Dr. Sally Ride is not with us today, or at least I don't see her, and she is pulling together the various studies NASA has been doing plus the activities of the National Commission on Space, which you may remember discussed a lot of that, and we expect this spring sometime to have a best guess as to what we ought to be doing in 1995.

Those are—I probably missed one or two—but those are some of the goals we have established for ourselves, and they are quite consistent with the national policy as expressed by the Congress and by the President, not only this President but past Presidents.

Now the problem is to fit programs with those goals, and hopefully we will come back to you and make some suggestions to that effect.

Mr. HAMILTON. Thank you, Dr. Fletcher. Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman from Indiana. Let me ask this question, just to get the question clear.

What is the process you are following on retrofitting the other three orbiters that we have? Is that all being considered as part of this package?

Dr. FLETCHER. Yes, indeed. All the orbiters will be retrofitted with the safety and reliability features that will go in the first flight.

I have to remind you, one of the orbiters does not have the full payload capacity. That, of course, won't be upgraded to have the same payload capacity but will have all the reliability and safety features.

Mr. ROE. Where I am coming from, there is an assumption here, I recall part of our oversight investigative hearings, when we talked about, for want of a better phraseology, the pirating of parts—do you remember that issue—from different existing vehicles.

Dr. FLETCHER. Yes, indeed.

Mr. ROE. Are you telling us as you are working out your program vis-a-vis the new orbiter, all of the existing units will be retrofitted in kind from a safety point of view?

Dr. FLETCHER. Yes, indeed, Mr. Chairman. That is one thing I should have mentioned earlier in terms of making the future Shuttle missions much more reliable. We have got marked improvement in our organization in procedures, and the spare parts procedures are part of that. We have completely restructured our management and have taken a look at our procedures, tightened them

up so that everybody is accountable for what he does and knows he is and knows what his reporting relationship is, and all of those things will avoid some of the mistakes of the past.

Mr. ROE. Does your programming and your budget requests cover those elements?

Dr. FLETCHER. Yes, the programming in the budget request does cover all of the things that were mentioned in terms of making the future Shuttle missions safe and reliable. I should add, though, there will be outyear costs as well.

Mr. ROE. I understand that, but what I am trying to get clear for the record is we are coming back, and as the gentleman from Indiana has pointed out, if we are looking at the universe of our Space Shuttle Program, in order to be a safe program, we have to provide adequate funding not only for the new orbiter but for the retrofitting of the other orbiters. Is that correct?

Dr. FLETCHER. Absolutely.

Mr. ROE. Has your budget request reflected that?

Dr. FLETCHER. Yes, it does.

Mr. ROE. I thank the gentleman.

The gentleman from Florida, Mr. Nelson, I beg your pardon. The gentleman from Kentucky, Mr. Perkins.

Mr. PERKINS. Doctor, it is a pleasure to have you with us today.

I just have a few questions that spring from—of course, I haven't had the time, as a new member of the committee, to digest everything necessary in terms of the past that we have seen, but last year I was reading this National Commission on Space report, and in there several things come to mind as I am sitting here. One was an indication in there that there were two means you were looking into, either some sort of supersonic transport way of getting into space in a plane way, or the other way was a reusable rocket.

What element are we at now?

Dr. FLETCHER. This is part of our future transportation study. Let me see if I can recapitulate what is involved. We have a national aerospace plane project, as I mentioned earlier, which is a cooperative program with the Defense Department, it's an airplane of sorts which takes off from a normal airstrip, and if we do it right, we will achieve Mach 25, which is enough to get us into orbit, and then return back through the atmosphere at very high speeds. That is an advanced technology program cooperatively with the Air Force, and we are doing the technology part of it. That aerospace plane is scheduled to have an experimental version in 1993-1994 time period.

If that is successful, we have two offshoots of that. One is a high-speed transportation system, so-called Orient Express the President refers to, or it could be a people-mover to and from space. Of course, we are interested in the latter, and the Defense Department and commercial are into the former. That is just a piece of the program.

We also have an advanced shuttle which will be a people-only transportation system, but hopefully much less expensive and also much more reliable.

Neither of these two programs will give you reliable, safe transportation until past the year 2000. It is out in the time when the Shuttles are beginning to wear out and be obsolete.

In addition to that, though, we have decided very clearly within NASA that we need something that transports cargo to space. This is just materials, spacecraft and so forth, planetary missions, without people to space, and so we have several studies along that line. But the main one is a joint study with the Air Force, STAS, I have forgotten what it stands for, for a heavy-lift launch vehicle. But that also includes low cost. The only way we can move out in space, as I indicated earlier, is to have a lower cost transportation system.

Mr. PERKINS. You are indicating to me at this time we are moving in a direction of going for the MACH 25 plane as opposed to the reusable rocket, and that is a conscious decision that has been made, and that is part of the policy effort?

Dr. FLETCHER. That is a conscious decision that has been made to look at the experimental plane. We have not made the decision to go ahead with an operational vehicle yet, but that is certainly a good possibility, but not the only one. We have other possibilities as well. We are all competing with each other. The advanced shuttle program is competing with the national aerospace plane.

Mr. PERKINS. What type of time frame are we looking at in terms of some sort of decision-making process? I notice they asked NASA for some sort of recommendations in that report by December of the year, and then I understand through asking—through staff that that was changed to approximately March 15 deadline.

What is the current status of that, and when can we expect that report?

Dr. FLETCHER. The response to the National Commission on Space is, of course, the responsibility of the White House and then the organization that has got the ball, so to speak, is the OSTP, Office of Science and Technology Policy, however. We are not just waiting for their recommendations. We at NASA are preparing our own response.

What we think, at least the early part of that—see, they had a 50-year program, and we want to look at the first 20 years or so to make sure what the budget run-out will be in that early period, and we will have our response ready this spring as part of this new space initiatives program.

That is related, of course, to the study by Dr. Sally Ride, related but not the same. In response to the National Commission on Space, it is going to be required, I suspect, from NASA. We also have our own internal program which is what we ought to be doing in the post-1995 period. Both of those are planned for this spring sometime.

We haven't got a definite date because we have to be responsive to the OSTP requirement as well.

Mr. PERKINS. I see my time has expired. I will try to be quick. It seems to me one of the things we are talking about here today is trying to develop some type of long-term plan of where we are going to try to fit in our short-term objectives to fit the long-term plan. This spring are we going to be seeing enunciated, at least from NASA, what their concept is for a period of time the next—let's not go 50 years. Let's go 30 years.

Dr. FLETCHER. I would say, Mr. Perkins, you will get two things if we do our job right. One is a response to the Paine Commission, which was a 50-year plan, as you recall. It will give you our best

guess as to how to respond to that. In addition, to that we will have a longer range plan which deals with what we should be doing beyond the Space Station, and that is more near term, let's say, the next 20 years instead of the next 50 years. Hopefully, both of those will be available this spring.

Mr. PERKINS. Thank you, Doctor.

Mr. ROE. The chair recognizes the gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman. I want to compliment you all having gone through the bureaucratic maze down at OMB and having come out quite successful in increasing the budget in 1987—for fiscal year 1988 over fiscal year 1987 almost $2 million.

You are to be complimented. You are also to be complimented on taking the Paine Commission report seriously with regard to the account on space research and technology and increasing that from $171 million to $250 million, and we applaud you for that.

We think we are going in the right direction. Mr. Perkins' comment about the—your comments on the Paine Commission, you will recall both the House and Senate agreed we are looking forward to your suggestions of how you would implement the Paine Commission report on April 15 this year.

Now, let me ask you a couple of specific questions here.

Do you anticipate your recommendation to us for the cost of the Space Station will be in excess of $8 billion?

Dr. FLETCHER. Yes, Mr. Nelson. The $8 billion was an estimate made in 1984 or thereabouts, and it was a best guess at the time. We now have hard data from contractors and from our own grass roots analysis, and it is clear it is more than the $8 billion, considerably more, but the exact number a little reluctant to circulate simply because we are not—we have got two different estimates at least, and we have to reconcile those, and we don't want to come out with a number, and then have to change it three months later.

So we are very close to a decision on what—by the way, grass roots and a top-down estimate, both of those things we have done and agreed upon with an appropriate reserve. There is a lot of uncertainties in this Space Program, and we have to allow an adequate reserve for those uncertainties.

Mr. NELSON. Let me just stop you there. Your answer is yes. Okay, now, given that fact, why is your request to the Congress in fiscal year 1988 a figure for the space station something similar to $767 million. When you came to this committee, you generically, NASA, not you specifically, you came to the committee last year in a plan of some five years of construction of which we authorized and was appropriated $410 million in fiscal year 1987, but the progressive schedule for fiscal year 1988 was $1.1 billion?

So why have we—if the station is going to cost more than $8 billion, why are you coming forth in the second year with less in your request to the Congress?

Dr. FLETCHER. Mr. Nelson, that is another awfully good question. We, quite frankly, had a lot of hoops to go through—we are still in the process of going through. The discussion earlier about the release of RFP's is a good question in point. We planned to release those in December last year. We had also expected to have our costs in line.

As you know, we went through a very large configuration change, not changing the work packages significantly, but a big configuration change, and now we have to look at options for keeping the costs down, not that we will not go ahead with the full configuration, but in case there is problems about the increased cost estimate, we are behind schedule some, and the 767, to our first approximation, fits that schedule.

I remember we may have some of the $160 million left over from fiscal 1987 to apply to the development. But whatever the case, we are not moving as fast as we had hoped to when we were here last year.

Mr. NELSON. Are we getting into the situation, Mr. Chairman, again reminiscent of the early seventies in which too much was being expected of the existing availability of dollars and maybe we ought to be in a situation where either we have got to greatly scale back our expectations of what we are going to do, which I think would be a drastic mistake for the future of this country, or do we, if we have the expectations, and they are reflective of the will of our people, that then we ought to offer the dollars available?

Do you want to comment on that? In other words, shouldn't your budget be $10 billion instead of $9½ billion so we can take care of Mars Observer and ACTS and all of these other things and have a science budget that is not being reduced in 1988 or 1987?

Dr. FLETCHER. I think your comment is well taken, Mr. Nelson. Our budget isn't high enough to do all of the things we know we need to do. Part of that is our fault. We didn't have our act together when we went through the budget process this year, but part of it—let's face it, the Nation has a very serious budget deficit problem, and we have got to be cognizant of that when we go through it.

That doesn't mean we shouldn't ask for the right amount of money, but it does mean we have to be careful to justify that amount of money, and we really didn't have our facts lined up to justify a higher budget when we went through this.

Mr. ROE. Will the gentleman yield? I think the gentleman from Florida is coming from where the chairman is starting to come down. We are all aware of the extraordinary budget deficits, but there are also other issues involved. It is not the deficit alone that concerns us as much as what kind of priorities, our present administration, what kind of priorities is this committee going to place on that.

What he is asking, what I hear, is if we are going to be doing up front a program on the space station, the question really is if you have additional funding, could the program be accelerated.

Dr. FLETCHER. There is no question about it. If we had the right amount of funding for expendable launch vehicles, we would have a better space science program and a more reliable TDRS.

Mr. ROE. Aren't we saying, then, if you had your druthers and work under the constraints you work under, we respect and understand that. If the committee decided on the basis of the facts we have before us to recommend higher funding, because it is the priority and interest of the nation, could you perform under that added funding?

Dr. FLETCHER. Yes, indeed, Mr. Chairman.

Mr. NELSON. That says it all, and Mr. Chairman, you and I are on the same wave length and it boils down to this. How do you put 10 pounds of goodies in a 9½ pound sack?

Mr. ROE. I agree. There is one other point you might want to clarify that might be profitable at this point. Mr. Myers discussed earlier you are planning on meeting the 11th of February further, as I understand it, on the international aspect.

Let's take a hypothetical case, and I happen to agree with you. I think the idea we spend an artificial figure on an achievement is just ridiculous thinking. Let's take a case. Suppose for the sake of discussion you recognize the space station and the facts we have before us as we are generating now cost $13 billion.

Let's just take that figure out of the air for that matter. What proportionate share, as you are negotiating, will the international community be providing toward that $13 billion?

Dr. FLETCHER. As you know, Mr. Chairman, the foreign participation is an additional $3 billion to whatever costs we come to you with, which is our honest cost for the Space Station, be it $13 billion or whatever, will have to be added on. The $3 billion or so, our foreign partners will be contributing. So the total, of course, will be higher.

Mr. ROE. That is precisely the point I wanted to get on the record. Therefore, we are coming back and saying when we speak, whether it is $8 billion, $9 billion, $13 billion, whatever the case may be, the figures you are speaking to there are those figures that will be our exposure as far as the United States is concerned; is that correct?

Dr. FLETCHER. Yes. That is all we will do, and quite frankly——

Mr. ROE. I think it is very important to get on the record right now, because there is all kinds of figures floating over the lot, and I have a respect for you not being ready right now to tell us specifically. You need a little more time. We understand that, but where we are coming from, we are saying in order to do that, the overall program is going to cost $16 billion, whatever and a proportionate share of that will be borne by our foreign participants.

Dr. FLETCHER. That is a fair way of saying it, but in all honesty they are going to have to go through, the Japanese, Canadians, and Europeans, the same exercise we go through and pin down their estimates of what they are willing to do than we. The $3 billion we keep talking about, they will add to whatever we come to, may be a larger number, too.

Mr. ROE. That is what I am thinking. In other words, I want to explore this further, because I think it is very important. For example, as we look at the overall costs, we are going to have to be presenting in priorities to the Budget Committee, for example, people just recently—I understand the White House is discussing the point of view, going into the accelerator program, and so forth.

The Superconductor is what I am thinking of. That runs somewhere in the order of magnitude of $6 billion. So when we start talking about the figures of today, we are talking about considerable funding to get all of these things into focus, so on and so forth.

But it would seem to me—is there a possibility our international participants could be putting up additional funding, a greater proportionate share?

Dr. FLETCHER. It is certainly possible, Mr. Chairman.

Mr. ROE. Half of nothing is nothing. If we don't fly, they haven't got anyplace to go in the first place. Should there be a larger share being put up by our international partners?

Dr. FLETCHER. It is certainly possible, but I have to add our first hurdle is to get some sort of agreement on how we are going to run this program, and I hate to complicate it by, at this point, asking for additional funds, but it is certainly possible they will put up a large proportion.

Mr. ROE. There is not going to be any program at all for them to participate in unless we figure our how we are going to do it, and we have to do it soon, is where I am coming from. What proportionate share do they put up anyway? How is that arrived at?

Dr. FLETCHER. Well, I might want to ask Ken Pedersen to respond to that because I was not involved in the earlier negotiations. We did find out what it is they are going to build. It is clear Europeans, will lend a complete attached module, as we call it, an experimental laboratory model. The Japanese will also build one complete laboratory module with part of it manned and part of it unmanned.

The Canadians will build a remote manipulator on this, which is a key part on assembling the Space Station, and also in preparing and retrieving payloads. Conceptually we have defined what they are going to do. I should have mentioned what we call free fliers platforms, the earth observation systems, which is the polar platforms. There will be another one, which will be flying in formation, so to speak, with the Space Station. They have made an estimate of what that total is or individual estimates. The total of that comes to $3 billion at this point. That $3 billion relates to the $8 billion early estimate of our own.

Mr. ROE. You weren't there, and I wasn't there. The point that's puzzling me is you have numbers of items that are going to be on this payload you can't get into space unless somebody puts it there, and we have to put it there. The question is, are they paying a fair proportionate share of what it is costing us to do this?

That's all I am asking.

Dr. FLETCHER. Part of our job, Mr. Chairman, is to be absolutely sure that they are paying their fair share.

Mr. ROE. Who decided the proportionate share they should pay?

Dr. FLETCHER. This was decided early on in negotiations between heads of State and we are in the process of implementing that. Now, there is some small changes here and there, but let it be clearly stated before this committee and everybody else that if their share is $3 billion and our share is $8 billion, they will get more than three-eighths of the use of that space station.

That, I think, ought to be clear to everybody, and that is the premise on which our negotiations are based. They understand that and so do we.

Mr. MYERS. I think it is important to make another point here. We originally had made this rough estimate of $8 billion. They originally in estimating the costs of those elements Dr. Fletcher described, estimated $3 billion. We now have gone through this grass roots estimate, a detailed top to bottom review of our activities, which is showing us our portion is going to be more than $8 billion.

I am not sure where the Europeans and Japanese are on the definition of the final equivalent dollars that are involved for their portions. It could well be their portions may end up more than $3 billion, so the dollar estimate of their portion has yet not been described finally.

Mr. ROE. Apparently, I am not asking the right question. I don't know what I am trying to say, but it is not coming out. Where I am coming from, just for clarity in the record, we are going to have to ask for $x$ amount of billions of dollars to achieve this goal.

Where I am coming from, is our experimentation going to take place related to what they are doing in the sense of the costs that are involved? Are they paying part of operation and maintenance costs? Are they—in other words, they are paying their proportionate share, and the rest we are going to be picking up, but we have a comparable amount of experimentation on the same relative basis there.

Do you get where I am coming from?

Dr. FLETCHER. They are not only paying their fair share of the development costs, but also their fair share of operational costs which go out in time for 20 or 30 years, and that is the basis for the negotiations. They understand it and so do we.

Mr. ROE. Do you think it is worth our expending $8 billion on this program? Should we scrap this space station? Should we scrap it?

Dr. FLETCHER. I don't think so.

Mr. ROE. That is being talked about. There are people out there saying we shouldn't do this and it is not—it is a mission we are trying to make happen. Should we do it or shouldn't we do it? If we should do it, shouldn't we be up front with it and say we have to have the money if we are going to be able to do it all if it is national policy basically?

Dr. FLETCHER. It is inconceivable to me we would move in that direction. I can't imagine the Congress doing something completely at odds with the wishes of the American people.

Mr. ROE. I am not so sure about that. I am not so sure the American people—I am not being facetious. I am not sure the American people understand it, Number 1, to begin with. We just got through saying we have to think about what kind of program we are going to have.

We don't know what we need on expendable launch vehicles. We have these parts and pieces all over the country, haven't been able to get them up there, and so forth. Why should we be doing that? Why should we be going ahead spending 8, 10 or $11 billion on the space station when we can't get the rest of it done? I am not being facetious.

Dr. FLETCHER. I didn't mean to be facetious either.

Mr. ROE. Did I suggest that?

Dr. FLETCHER. I think it is an extremely important program to the Nation because of its scientific and even commercial potential, but perhaps more important is the symbol of American competitiveness in the world. All of these things are reasons why we need to go ahead with the Space Station of the appropriate size and function.

Mr. MYERS. I think another point that comes into this is that the Space Station has in every major review of long-range goals of our space program by every group and committee that has worked on it has always been an integral part of the eventual long-term goals that we may have in space.

Mr. NELSON. Mr. Chairman, you might wonder aloud since we are on the question of dollars: Was any deal struck last night at 11 o'clock by Dr. Fletcher and the Defense Department over what Defense might contribute, if anything?

Mr. ROE. I think what the gentleman is saying, has any arrangement been arranged?

Dr. FLETCHER. Mr. Nelson, Mr. Chairman, the Defense Department is really not a part of the Space Station, they have not requested in any way the use of the Space Station. We have always made provisions for research that the Defense Department might want to make, do on the Space Station, because once it gets up there, everyone will want to use it, believe me.

But the negotiations were simply, they wanted to be sure that we haven't X'ed them out of the program. They have made no request to be on the Space Station. Reciprocally they have made no suggestions about contributing to the space station. I am not sure—there is pluses and minuses to do if they were to offer to do so. You don't get anything out of the Defense Department for nothing. If we got money from them, they would put restrictions on that might not be acceptable to us.

Mr. ROE. I think you are making a very important point, there are a lot of people around Congress wondering whether or not NASA is going to survive as a civilian space program, or is it going to go to DOD if we have to piggyback and do our relationships with DOD, many members on this committee, including this chairman, are concerned about that issue.

And where we are really coming from, we recognize there should be some balanced program, but we shouldn't necessarily have to piggyback on Defense. I think that is where the gentleman from Florida is coming from, and I am too. Why don't we just be up front and say to ourselves what our short-range goals are and what we can do, we are capable of doing it. Isn't it the question of whether or not we want to put the resources into doing it? Isn't it Congress now has to make a decision on priorities, whether they want to put those resources at your disposal to get this job done?

Dr. FLETCHER. Yes.

Mr. ROE. Well, if we are saying that, if my committee members will indulge me for a moment, what we are really saying is that the committee has to decide on the facts before them what kind of recommendations they are going to make to Congress, what we see to be the need. Is that a fair commentary to make?

Dr. FLETCHER. I think that is right on, and I will have to quickly add, we will supply as much information to that effect as we can.

Mr. ROE. The chair recognizes the gentleman from Iowa.

Mr. NAGLE. We had the opportunity to review the flight of the Voyager, the testimony of the crew indicated they had used a number of what could best be described as innovative techniques to obtain that, composite materials that hadn't previously been used,

aerodynamic designs, and they had some vivid experiences on the psychological implications of flying at slow speeds for long spaces.

They also testified before they left, no one from NASA has ever contacted them about their aerodynamic designs, materials, or the composite material. First of all, is that true, no one from your agency has contacted them?

Dr. FLETCHER. I would like to defer to Mr. Colladay on that. Let me quickly add the technology they used on the Voyager flight was largely NASA technology, the winglets, the composites that they used, the idea of using lean combustion in their propulsion system, many other things that over the 71 years of NACA's existence all contributed to the success of that flight. The direct answer to your question, I don't know.

Dr. COLLADAY. I would like to make a comment, because it is a good question.

Mr. NAGLE. Can we start by answering the question? Have you contacted them after the flight?

Dr. COLLADAY. I don't believe we have contacted them after the flight. We did work with Burt Rutan on the development of the vehicle at Lewis Research Center and offered consultation with them, with him and Burt, whenever requested after the flight. I do not believe there has been any direct contact.

Mr. NAGLE. The second obvious question would be, do you plan on contacting them?

Dr. FLETCHER. Yes, we will, as we try to capitalize on many of the technologies that were incorporated into the Voyager vehicle, just as that vehicle capitalized on the technology base NASA developed over the years. We developed a technology base from which everyone draws from. That, to me, is a success story of the program that we have developed over the years.

Mr. NAGLE. I received the impression from them they seemed quite eager to talk to NASA. They learned some things, not that they didn't trade on what you gave them, they had learned some things and were eager to share information with your agency. When can we anticipate you would talk to them?

Dr. COLLADAY. We will be in contact with them today.

Mr. NAGLE. I have their phone number here if you need it.

Mr. Chairman, if I may pursue this.

Mr. ROE. Of course.

Mr. NAGLE. Sitting here as frankly a newcomer on the committee, but listening to your explanation of the budgetary process, I gather there was more time constraints on you to present this budget—is that fair, Dr. Fletcher.

Dr. FLETCHER. Yes, it was a very fast track, Mr. Nagle, and I don't think that that necessarily compromised it. Our main problem was we didn't have all the facts necessary to justify all our needs. We justified all the needs that we knew at the time, and I think we were appropriately funded, but there were some left over.

Mr. NAGLE. I guess in light of that, to me it undermines my reliance on the credibility of the budget process. Are you saying if you had it to do over today, with more time, you would give us a different budget?

Dr. FLETCHER. Yes. No question.

Mr. NAGLE. Could you furnish us how the budget would be different?

Dr. FLETCHER. It would be hard to give you numbers without running those numbers by OMB, but we would have a larger funding for expendable launch vehicles. We would probably have additional funds in there for what we call advanced space technology connected with the new initiatives beyond 1995. We really got to get our act together on the longer-range planning.

And then, in addition to that, we do have to deal with a number of other problems which have since come up having to do with the Mars Observer, for example, and other science programs.

Mr. NAGLE. I haven't been in the institution long enough to learn the refinement of language people practice here, but I don't want to cheap-shot you, but are you—what are you really saying—this isn't a very good budget you have given us and you could do a better job?

Dr. FLETCHER. If I had the facts then, when we were going through the budget process that I have now, I could have done a better job.

Mr. NAGLE. You are saying we shouldn't enact this budget if you want the best budget?

Dr. FLETCHER. That is kind of a negative way of saying it. I would say enact this budget, we will give you whatever is necessary to revise the budget in the next two to three months.

Mr. NAGLE. Thank you for your candor.

Mr. ROE. The chair recognizes the gentleman from Oklahoma, Mr. McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman.

Dr. Fletcher, I appreciate the comments of my friend from Iowa, and earlier the gentleman from Kentucky, because they raise two more points that sometimes are overlooked, and that is NASA does have aeronautics in it, and the first "A" is for aeronautics. I was pleased to hear in your long-term goals, the first one you called from the top of your head is that we maintain excellence in aeronautics.

The chairman of the subcommittee has jurisdiction over that budget, I have a series of specific questions that I would like to ask. First of all, I guess it is in conjunction with my position on the Research and Development Subcommittee of Armed Services that I ask you whether or not you are pleased or satisfied with the DOD–NASA joint management structure. If not, how would you correct it?

Dr. FLETCHER. I think we have come together on that, Mr. McCurdy. The National Aerospace Plane is a very complex plane. The experimental plane expected in the early 1990s will be largely based on NASA technology. And so the question is how to manage this program in a way that makes maximum use of NASA's technology and yet the Defense Department pays for a larger share of the costs and, in fact, manages the program.

Mr. Colladay may want to comment further. I think we have reached a good agreement on how that should be managed, what its focus should be, what technologies we need to make sure the first experimental plane works.

Mr. McCURDY. I think it is important we emphasize the first plane is experimental. It is a research platform. It is not going to be an airliner or space shuttle someone can go jump on it and take off on it. It is a platform to develop technology that can be transferred hopefully for other missions, is that not correct?

Dr. FLETCHER. That is absolutely right. We call it the X-30, kind of related to the X-15 and other experimental planes. It is an experimental plane, yes.

Mr. McCURDY. Do you have sufficient influence to insure that those resources are redirected properly and that you are going to have the proper support from DOD? DOD's budget is constrained also in spite of a lot of—what a lot of people think, or certainly in this institution, that they have conflicting priorities, and if they are not getting what they feel is enough of a return, isn't that going to put you in considerable bind?

Dr. FLETCHER. Well, in the fiscal 1988 budget, it is my understanding they are putting up their fair share, and there was some——

Mr. McCURDY. We will make sure it at least gets through the authorizing process, they put in their fair share.

Dr. FLETCHER. I want to add one more thing, and that is Dr. Ray Colladay may have a quiet voice, but he has a very large fist. And he doesn't allow very much to go on in those relationships we don't know about and that aren't acceptable to us.

Mr. McCURDY. The aeronautics budget remains flat this year. Is that——

Dr. FLETCHER. I don't believe that is correct. If you add the National Aerospace Planes——

Mr. McCURDY. The second part of my question was, is this due to the increased requirements or the increased budget for the Aerospace Plane to trade off basically——

Dr. FLETCHER. We feel the National Aerospace Plane is kind of a technology platform. It really is a way of testing some of these high-speed flow characteristics that we cannot test in any other way. It is really equivalent of a wind tunnel which we couldn't build on. So that is part of the aeronautics R&D base and should be considered such.

Mr. McCURDY. One of the concerns that Chairman Roe and I share—as did Mr. Hamilton, since we were all on the Intelligence Committee together, in addition to our position on Armed Services—is the utilization or the space availability on our launch vehicles and exactly where we are going in the future. I think there is going to be a great deal of pressure on NASA to eek out its fair share—some of us who support the civilian space program and want to assist—I think there has to be in your long-term planning some better coordination, and there is going to have to be some strong decisions made and advice rendered from your standpoint. That is an unsolicited comment.

The question I would like to ask, if I may, Mr. Chairman, relates, since you were the author of the Fletcher Commission on Defenses—I am taking the opportunity I have to have you before us—on SDI, General Abrahamson told me last week that—and I am consolidating, breaking down what he said, basically in his opinion it would be a mistake to deploy in a phased manner or quickly a

terminal defense, ground-based terminal defense, without a booster phase, that concept. In other words, without the booster phase intercept, it would be a waste of money, in effect, to go to the terminal base. I know that you are wearing a different hat now, but do you have any comments on that?

Dr. FLETCHER. I wouldn't dare in front of this august body try to contradict General Abrahamson.

Mr. MCCURDY. Secretary Weinberger has and Secretary Shultz. They have far less knowledge about this than you do.

Dr. FLETCHER. Your question is a good one. I have a NASA hat on today, and I am not sure I am current.

Mr. MCCURDY. It is worth a shot. I appreciate it. I understand your problem. I think it is something the committee ought to be alerted to, and the fact that there are some problems out there and that we don't have as clear goals in that program as in some other programs, and we need to, if Congress does its job, we can't micromanage, we don't want to micromanage NASA, we don't want to micromanage the Department of Defense; but in the absence of clearly defined goals, as Members of the Board of this nation, then the Board of Directors, which is what our role actually is, it is incumbent upon us to force out some clear policy statements, and that is what I hope that you can accomplish.

And once those are agreed upon, then I hope we will help write some checks, and you guys can implement the program. That is my comment.

Dr. FLETCHER. I will match my long-range planning, our long-range planning at NASA against the long-range planning of the Defense Department and SDI any day of the week.

Mr. ROE. The chair recognizes the distinguished gentleman from California.

Mr. KONNYU. Two companies I know are exploring and building a hybrid that is liquid and oxygen booster rockets and—I'm over here—These rockets have claimed advantages over solid rockets; that is better performance, nonpollutant exhaust, shutdown capability and safe on the launch pad.

Within the budget as a line, line 88 named the civilian space technology initiative, could you explain, in shorthand, that part of the budget to us and whether there is any booster technology in that portion of the budget?

Dr. FLETCHER. There is booster technology in this part of the budget, but I think we ought to ask Mr. Colladay to respond to the details of that.

Mr. COLLADAY. Yes, there is a booster technology element, and it primarily is in three areas: pressure-fed boosters as possible replacements for the solid rocket motors as an option somewhere in the future, and hybrid systems, hybrid solid and liquid oxidizer concept. There is a small amount in that program as well as for some of the basic materials and structures analysis of filament-wound case boosters as well. Those are the three areas covered in the technology program.

Mr. KONNYU. What is the intention in including those in the program? Is it an initial exploration, or is it a serious intention to switch technologies to hybrids or to—what is the intention?

Mr. COLLADAY. The intention is to do the research to understand the performance in things like combustion stability and overall thrust performance with full-scale engine firings just to get the knowledge and the understanding so a decision in the future can be made. We never fired at high pressure levels these kind of boosters with pressure-fed systems, and very little work has ever been done in large scale on hybrid systems.

So it is developing the understanding that needs to be in place before any decision can be made. It doesn't reflect a decision at this point to deviate from the current plan of the solid rocket motor or redesign.

Dr. FLETCHER. I think it is fair to say what we haven't done since we developed the space shuttle main engine, which was a major advance in engine technology, is really make the investment on longer-range technology for future propulsion systems, including propulsion systems that are necessary for boosters of the future. What Ray Colladay is trying to do is make up for that lack over the last—it must be 15 years—I don't want to say neglected but underfunded the space technology program, and booster technology is an important aspect of that. If that is wrong, Ray.

Mr. COLLADAY. That is absolutely right, and I would say it is from neglect of ten or 15 years. I think that is right.

Mr. KONNYU. Would you then specifically comment on—and these folks sat in my office, the company sat in my office and explained the advantages I listed for you. I will list them again. The comment I am asking for is what is your judgment as to the rest of those comments as to the advantages that hybrids have, that is first of all, better performance, next was nonpollutant exhaust; third, shutdown capability; and fourth, safer on the launchpad.

Are these realistic advantages in your judgment?

Dr. FLETCHER. Yes, indeed Mr. Konnyu. All of those are advantages, certainly the shutdown capability. The hybrid technology is something that I made a lot of mistakes when I was there before and that is one. We should have had the money to invest in hybrid technology because it has a lot of promise for future boosters. I could go into why that is but maybe it would take up too much time of this committee. But those are all real requirements of the future.

Mr. KONNYU. I would like to switch to an entirely different area. I have gotten I guess about 35 letters in support of the Mars Observer. Without being redundant, would you like to make any additional comments that you have not already made?

Dr. FLETCHER. I think most of the letters that you have received are on track. We have received some, too, needless to say. Some of them are of course from scientists themselves that feel that we started the Mars Observer program, why don't we finish it on the original schedule if we have the option to do so which it now appears from what Mr. Myers said we do. We haven't finished our negotiations with the Defense Department but it is looking better.

Some of them are simply from people that, from the general public that say Mars is an interesting planet, look at the interesting things you did in '76, let's get on with the follow-on to the '76 robot landings.

Mr. KONNYU. Thank you.

Mr. ROE. The Chair recognizes the gentleman from North Carolina, Mr. Price.

Mr. PRICE. I would like to pick up on Mr. Konnyu's line of questioning. In your testimony you say you are carefully considering the options for recovery of the planetary program. Could you elaborate not just with respect to the Mars Observer but the longer range elements of that program?

Dr. FLETCHER. Yes, Mr. Price. We have four funded major planetary programs, major the Magellan, Ulysses, Galileo and Mars Observer. We also have plans for the future as to pursue two kinds of planetary programs, the so-called—I don't know the exact name but the Observer program is a low-cost program which allows us to explore through orbiting planets, primarily planets near-by with scientific instruments. There are a series of Observer missions that are scheduled out in the 1990s that we plan to go ahead with.

The other kinds of missions are, I have forgotten the technical term, Mariner Mark II. We used to have a program called Mariner. This is Marine Mark II which the first one of those was the Voyager mission to Jupiter, Saturn and Uranus, and now Neptune. We expect to go ahead with the Mark II programs and I don't know what the first one would be, but the scientific priorities would be to move to Saturn and to explore Saturn the same way that Galileo plans to explore Jupiter.

I guess I am reminded there is also a mission to a comet and everybody has their favorite comet, but we learned a lot from Halley's comet, we the world did, although U.S. participation was small but it got us all excited on the comets as a fundamental constituent of any new solar system that might be created. So there is now renewed interest in cometary expeditions as well. But these are all planned programs, not funded but the scientists do a very good job and we talked about long-range planning, the scientific community does a first-rate job in assigning not only what we ought to be doing in the next 20 years, but what the priorities ought to be, which ones come first.

Mostly we tend to follow their priorities.

Mr. PRICE. Is it possible to put any kind of projected date especially on the Venus and Jupiter mission?

Dr. FLETCHER. Yes. On the Venus mission that is the Magellan, I think the flight—I will have to do this from memory and Admiral Truly will correct me if I am off, Magellan will probably be the first planetary flight on the Shuttle. I think that is scheduled for early 1989 and then the next two are being argued about which comes first, Ulysses or Galileo, and Ulysses is a cooperative program with the Europeans to explore the solar pole—that is the region above the sun's north pole which we have never done before.

Things ought to look quite different than the equator which the earth finds itself in the solar equator. That is a joint mission and a very important mission which we have developed with the Europeans. Then the Galileo is the Jupiter mission that I explained earlier. We have not decided what the priorities are between them, but hopefully we can get both of those launched on the Shuttle in the 1989–1990 period.

Then the Mars Observer would be off-loaded onto an expendable launch vehicle.

Mr. PRICE. Is the Ulysses mission the only one of these that does involve other nations?

Dr. FLETCHER. It is the major one. Galileo has—I guess all of them really have—some European experiments. The Galileo has major experiments being developed or having been developed by the Germans. It is not a European space agency contribution, it is a German national contribution on the Galileo mission.

Mr. PRICE. Thank you. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the gentleman from Maryland, Mr. McMillen.

Mr. MCMILLEN. Thank you, Mr. Chairman.

Dr. Fletcher, I was not here earlier in the hearing but I am interested in the safety factors surrounding the Shuttle, particularly in fiscal year 1988. Out of the $3.7 billion in space transportation system dollars, how much of that in your opinion will be earmarked for redundancies and backups on the Shuttle program?

Dr. FLETCHER. In the fiscal year 1988 budget to actually "fix" the Shuttle—fix is in quotation marks I suppose—is something like $300 million for sure that we know about, with another 100 or so reserve for things we don't know about yet. Four hundred fifty million, there-abouts is for that purpose.

Mr. MCMILLEN. And that 400 million will be the proper backup in redundancies on the one shuttle or will it be all the orbiters?

Dr. FLETCHER. All the orbiters, Mr. McMillen. We really have to fix them all, we cannot afford to have one of them deficient.

Mr. MCMILLEN. Okay, so basically 400 billion out of $3.7 billion.

Dr. FLETCHER. That is an off the top of a head guess. I think $300 million would be a better figure but we have got reserves there on top of that.

Mr. MCMILLEN. Fine. The second point I wanted to make is that I guess there was an article in the Washington Post a couple weeks ago about the frustration that a lot of senior scientists are seeing in 20 years lead times to see their projects through fruition. One of my concerns as a newcomer to this committee that we repeat the same mistakes we have read about in the Department of Defense where we try and fund everything and I think the Chairman and Mr. Nelson were alluding to this, yet we are not really focusing on the real priorities.

My concern in looking at this budget as a newcomer is that I don't get a sense of what really, really is important. There is a lot of funding for a lot of things and I am concerned about the brain drain that may arise from not having the sense of accomplishment of seeing anything done to totality, but rather we are trying to dabble in a lot of areas.

I am following up on the questions that were asked earlier, do you, how do you address that issue?

Dr. FLETCHER. It may seem like we are dabbling in a lot of areas, Mr. McMillen, but that is because when we have a balanced program and it is divided more or less into three, major parts, space science which is where we try to keep it at about 20 percent of the R&D budget; aeronautics and space technology which is a major thrust but which Dr. Colladay just described. This is technology to

be provided to the whole Nation in aeronautics and space technology. Aeronautics is an old thing. We have been doing that for 70 years or so and we are second to none in the world in that area.

And then last but not least is the manned space program, the first stage of which is the Shuttle which we are trying to fix now; the second major initiative would be the Space Station. So if you look at it that way the space science, and then the aeronautics and space technology and then the manned space program, those are chunks which we try to keep more or less in balance as we go through the years. They are never quite exactly in balance, but more or less.

I probably left out something but those are the major steps.

Mr. McMillen. I guess the point I am making is given our budgetary conditions we will see the stretching out. You alluded to that in the space telescope. What I am concerned about is the frustration we are facing out there in completing these projects in some timely fashion.

Dr. Fletcher. The space telescope is one that only slipped two years because of the accident, the worst one, the 20-year one that you referred to is the Galileo. That is incredible how long that has taken and will take because even if we launch it in 1989–1990 it is going to take 6 or 7 years to arrive at the planet. And it started when I was here in 1977.

So that is almost ridiculous for a space scientist. How can he spend 20 years of his career in that kind of a program? Well, we are going to try to avoid that in the future but that is a worst case. There are none as bad as the Galileo.

Mr. McMillen. Thank you, Mr. Chairman.

Mr. Roe. The Chair recognizes the gentleman from Pennsylvania, Mr. Walker.

Mr. Walker. Thank you, Mr. Chairman. First of all I would like to ask whether or not we can submit questions in writing. I have several that we will not get to in this period and I hope you would get the answers back to us promptly to these several questions.

Mr. Roe. Are you asking unanimous consent to submit questions for the record?

Mr. Walker. I would make such a unanimous consent request.

Mr. Roe. So ordered.

Mr. Walker. Thank you, Mr. Chairman.

Dr. Fletcher, I think it is absolutely vital that we as your Board of Directors, as one of my colleagues stated earlier, to begin to sort out some of these policies and I hope in the next two years certainly we get that sorting out process done. If I sound a little hostile on some of these it is simply because I need to get to the bottom of these things so we can begin to sort them out.

We waltzed around the question of how much money the space station will cost without coming up with figures. The fact is that before the Senate I think you used the figure of $13 billion.

Dr. Fletcher. No, Mr. Walker, I did not. That was a misprint in one of the papers. One of the Senators asked me was it $13 billion. He had heard that somewhere. I said it is in the ball park and somehow that got translated into something I didn't say.

Mr. Walker. I understand within NASA there is a strongly viable argument that the figure could be as high as $15 billion.

Dr. FLETCHER. I have to give the same answer, that is in the ball park, too.

Mr. WALKER. But the problem for us is that we are really then talking about costs which are 60 percent higher, a hundred percent higher than the figure that we have kicked around now for some time and I will tell you that when you begin to talk about that and then you add in the cost of the flights, we are really talking about a 20 to 25 billion dollar program between now and the mid-'90s, whatever that means.

Now, the question that arises is, you know, what are we buying for that kind of money. For example, I have a hard time understanding what we are going to be able to do aboard this station that couldn't be done using the facilities that are now being developed in the commercial marketplace. Could you detail for me what this station will be able to do once we build it for that kind of money that cannot be done aboard those stations that are being developed within the commercial marketplace?

Dr. FLETCHER. Mr. Walker, that is a good question. I will start to answer the question but I will expect Mr. Myers and Mr. Stofan to add to what I have to say. There are a lot of things that must be done on the Space Station that I don't see how they can be done in any other way unless way off in the future the Europeans build something like this or somehow we are allowed to use the Soviet Space Station. Let me give you some examples.

Many of the microgravity experiments, this has to do with separation of biological materials and has to do with production of new semiconductors and new metal alloys, solid state physics, many of those require longer duration than the Shuttle can possibly do. With one exception. They must be done on the Space Station.

Now the exception is the private sector. We have a company, Max Sajet Companies Space Industries, Inc. and we have a Memorandum of Understanding with them and they are going to supply a permanent facility in connection with the Space Shuttle if necessary or the Space Station.

Mr. WALKER. But it has been determined that it can be built up, is that not the case?

Dr. FLETCHER. Yes, indeed, and they have backing from Westinghouse Corporation and so that will be a private sector initiative. I would imagine the people that use that facility will be people that have commercial ideas and want to keep their ideas more proprietary. But nonetheless that is at least one commercial venture. There are other commercial proposals that we are evaluating that will do similar things. So yes, the commercial world can contribute to this Space Station.

Mr. WALKER. But my point is what are we getting—well, let me start, ask one other question first, then come back to what I was saying before, there is one question I want to get on the record. For the $15 billion we spend, 13 billion, 16 billion we spend, whatever it turns out to be, for that amount of money, are we buying a fully equipped full capacity station? Are we getting the whole ball of wax for that amount of money?

Dr. FLETCHER. Mr. Walker, out West we call it the whole enchilada but that is all right. Ball of wax is fine.

Mr. WALKER. Okay.

Dr. FLETCHER. I started to go down the list of things that we plan to do and let me just say that all those things that I first described are what we call microgravity experiments, many of which have commercial possibilities. So there is a commercial aspect of that. In addition to that there are some things that we have to do in terms of preparing for moving people out into space and I don't think it is a trivial point. The life sciences particularly, the question of how people and animals behave under zero for an extended period of time. We have to understand that a lot better if we are going to move much further out in space. All of those things are unique to the Space Station.

Mr. WALKER. Well, that still doesn't—are we getting for the amount of money that we are talking about spending, the whole enchilada?

Dr. FLETCHER. The answer is yes.

Mr. WALKER. We are getting a complete station with all the power capacity, with all the modules on board, fully equipped modules capable of housing the numbers of people that we have spoken about up to now, we are buying everything complete for the money that you are now talking about?

Dr. FLETCHER. Everything complete, but I have to put a caveat on that; the free flyers, the so-called platforms have to have experiments inside and they have to be funded. Some of the attached payloads have to have science inside and they have to be funded. They are being funded on as a separate budget, but not as part of the Space Station budget. The microgravity, for example, we have, $30 million or thereabouts for fiscal year 1988 in there. That would be funded separately from the Space Station. But the facility that uses these scientific experiments will be complete, the whole enchilada, the whole ball of wax.

Mr. WALKER. My time is up and the Chairman has been generous but I come back to the points that everything you have described to me so far, microgravity research, permanently-manned, so on, sounds to me as though they are things that could be, largely be done on a build-up of some of the commercial space platforms that we can buy for one heck of a lot less than 15 or 16 billion dollars. Now, you know, since we have not defined this very well up until now I would really like to know what it is that is wholly unique about this. In all honesty your statement describes here, it says on page 4, symbolic values of the space station however may exceed its considerable practicality.

I will tell you, Dr. Fletcher, I don't think that the American people are in a mood to buy $16 billion worth of symbolism. It is in fact a great national symbol if in fact it is carrying out a mission that fits with a totality of the space infrastructure and so on. We cannot fly a mechanical version of the flag out there and think we have done our job.

Dr. FLETCHER. I am sorry the symbolic statement got in there. It wasn't meant to say that. That is not the main purpose of the Space Station. The main purpose of the Space Station are the uses I have described. I think that is so-called private infrastructure or the whole infrastructure is something that we are taking into account and I tried to indicate some aspects of that when I described

the space industry's proposal. There are others by the way. That is not the original one.

Mr. WALKER. Just for the record and the reason for asking the question is I will tell you that one of your people told us that the space station would be like "a starter cape cod where you have a room upstairs, add a couple bedrooms when you can afford them and then you add a bath when you can afford it and eventually you buy the whole house as you can afford it."

That was the way that it was described to us by one of your folks along the way. You know, I don't think that that is what we think we are buying for the money that we invest.

Dr. FLETCHER. Mr. Walker, I think your point is well taken but let me clarify something because it is clear that we are going to—our current estimate is higher than the $8 billion. We are looking at alternatives to keep that total price down and some of those alternatives may be what our colleague in NASA may have been describing. But the full-up Space Station that we described to you last year will have the capability of doing all of the things I described, but I think it is fair to say we will have the capability of being expanded into something broader. We have not mentioned for example the transportation node. That was part of the National Commission on Space's idea. That is an assembly place for missions to the planets, to the moon or whatever, where we can pull parts together, assemble them with remote manipulator sensor, the mobile manipulator, and launch them unmanned or manned to the other parts of the solar system. Those are the things that maybe our colleague was referring to. It does have that capability of being expanded to a transportation node.

Mr. WALKER. And I have said in the past I think that is very valuable to be able to do that. I think to put something up there that you cannot expand doesn't make much sense. I would agree with that. But if we are in fact defining missions for this, I think we want every assurance that when we get the space station up there that what we have paid for is something fully capable of doing all the missions that we have described from the very start, and the other question that occurs then is, is there some other way of doing those exact—those missions that is far less expensive?

It seems to me the other question—that is why I want to get these written questions to you—if we are going to spend those kinds of dollars and 20 to 25 billion is one whale of a lot of money, are there some other things we ought to be looking at as potentials? For example, would we spend our money more wisely going back to the moon at that kind of cost? If the cost of the space station is going to continue to escalate, would we be wiser to put those dollars towards going back to the moon and putting men permanently on the moon rather than spending those dollars for a space station we might be able to replicate at least in part with a far less expensive design done by the commercial sector?

I think those are questions that we as a committee are going to have to address here, and I think that you as a NASA will have to address. You will have to look by individual projects and decide whether or not the allocation of resources that we are contemplating over the next decade is in fact the direction we want to go in a totality of the space effort.

Dr. FLETCHER. I don't disagree with those comments, Mr. Walker. In terms of alternate ways of doing the same thing by the private sector or otherwise, we have exhaustively looked at that and I think we are comfortable there. In terms of alternate missions we might perform, almost any of them, such as going back to the moon, as you mentioned, require something like the Space Station. It might be a slightly different Space Station but we have to look and be sure that it does fit those requirements as well. But almost anything you can think of moving people beyond earth's orbit, whether it be to the moon or some intermediate place or even to Mars, requires something like the Space Station we have described as a first step.

We are trying to accommodate those in terms of our expandability. But the Space Station that we described to you last year will only have the expandability features but not be a transportation node as you described.

Mr. WALKER. More discussion to follow.

Mr. ROE. The Chair recognizes the gentlelady from Maryland, Mrs. Morella.

Mrs. MORELLA. It has taken a long time, Dr. Fletcher, but I remember when your predecessor was NACA and I once helped compile a dictionary on the National Advisory Committee on Aeronautics.

Dr. FLETCHER. You are in good company, Mrs. Morella, Mr. Myers and ourselves were on a committee in 1951 advising the NACA.

Mrs. MORELLA. Amazing. The questions I am going to ask probably can be very briefly answered. Maybe they have been alluded to earlier.

First of all, when my constituents say "Are we going to be able to resume the Shuttle flight in February 1988", what answer should I give them?

Dr. FLETCHER. Mrs. Morella, this is a best guess on when we expect to fly, February 1988. There are a lot of threats to that schedule. We don't slip schedules unless we have to, and otherwise we would be slipping them every week or so as new things came along. Right now we still think we can make that February 1988 date. But the chances of meeting that date are anybody can speculate on but that is our target date.

Mrs. MORELLA. Has it become more and more remote? I know the newspapers have picked up on the fact that maybe this is overly optimistic to consider that we would even be ready, but you seem to think we can stay on that course?

Dr. FLETCHER. I think we can stay on that course, Mrs. Morella, for the time being. Admiral Truly may want to comment but the last reading I took there were no threats that would cause us to slip that although there are many uncertainties about it and we may have to later, but at this time I have not heard of any real threats that would cause us to deliberately slip that schedule.

Admiral Truly, do you want to comment on that?

Admiral TRULY. Yes, sir.

Mrs. MORELLA. I wonder, do you get information to our committee before the press gets it or——

Dr. FLETCHER. Quite frankly, no. Today we did, yes. That is the exception. We got the information on the output of the sig-space product to you before the press got it but normally we don't have control over leaks of information and we cannot always assure that you will get it first.

Do you want to answer, Admiral Truly?

Admiral TRULY. Mrs. Morella, the recovery of the Space Station program is, I think, the most important goal that is going on in NASA this year—I am sorry, the Space Shuttle to fly.

We are on a tight schedule. We have got thousands of people across the country working to that schedule. We have been on this schedule to February 18, 1988 since last June which I think is a major achievement. I have also read in the newspapers that we are not on that schedule. I have heard people rumor it to me that we are not on that schedule, but my center directors and my program people have over and over worked the disconnects and it is still the schedule that we are on.

However, I would like to say and I think that you should pass on to your constituents that February 18, 1988 is not a magic date. If we are not ready to fly on that date for safety reasons, we are not going to fly. But we are going to get back to flight. We are doing extremely well, I think, and we have stayed on that schedule for some time. If we have to change it we will. We will certainly advise this committee if we have to. But we are not going to change it based on people that don't have the responsibility in the program for it.

Mrs. MORELLA. Right. So you are not starting off with the mindset that there is no way we can achieve it.

The second question I have has been alluded to and it has to do with the role of the DOD in the space station. I wonder, do you see DOD's involvement? I know the question had been asked about are they going to fund it and you said they have made no mention of that. I am curious about whether you could expand or mention briefly whether you see it as a civilian and DOD combination thing?

Dr. FLETCHER. Mrs. Morella, the Space Station is an international Space Station whose main object is to provide for science and commercial activity for a variety of industries and science programs. On the other hand, it is a permanent manned presence in space. I have worked on the DOD side of the question as was mentioned earlier. It is very clear to me that if and when it is up there—and I am sure it will be there in the mid-1990s because you all are saying you want it there—the Defense Department will want to come in and say, hey, we would like to use that, too. I am sure of that but the Defense Department has never requested any such thing.

Mrs. MORELLA. I had asked a question the other day which had to do with whether or not Mr. Weinberger had said that international negotiations would be held up with other countries unless we had assurances that there would be a possibility of strategic defense initiative on space stations. Does that sound familiar to you?

Dr. FLETCHER. Yes, indeed it does. We at 11 o'clock last night were able to settle our differences with the Defense Department

and we are on track for a February 11 meeting with our international partners.

Mr. ROE. Excuse me, would the gentlelady yield. I didn't hear that question and I would like to hear that question more clearly. I just didn't hear your question, I am sorry.

Mrs. MORELLA. Mr. Chairman, I had mentioned that the other day I was curious about whether or not our international negotiations were predicated in terms of what the Secretary of Defense wanted on space stations being used as strategic defense initiative and Dr. Fletcher—would you like to answer again?

Dr. FLETCHER. I simply answered that we settled whatever differences there were between the Defense Department and ourselves at 11 o'clock last night and we are on track for the scheduled meeting with our international partners on February 11.

Mr. NAGLE. Would the gentlelady yield?

Mrs. MORELLA. Yes.

Mr. NAGLE. Could you tell us what those differences were? What your position was and what the Department of Defense position was and what the reconciliation was?

Dr. FLETCHER. They were small differences but Mr. Myers was in the middle of a lot of those discussions and I think he can give you details. To me there were hardly any differences. They wanted to be just sure that we were not acing them out of the picture so to speak, and we never had that intention and the Europeans knew that.

But Dale may want to answer.

Mr. MYERS. Mr. Nagle, in the early activities on the Space Station the Defense Department clearly stated that they didn't have any requirements for the Space Station. As we began to get into the details of the negotiations with the Europeans on the agreements on how the Space Station would be used for science and commercial activities and so on, the Defense Department decided that they better find out if they were going to be able to use it if a requirement came up.

So actually the issue was a matter of sitting down and understanding how the Space Station would be used, how to protect research activities that might be entered into by the Defense Department from other people's knowledge and in fact, we have done a lot of work on the proprietary aspects of our American industry anyway, so it was a matter of dealing with those issues.

Those have been settled as of last night and we are continuing now——

Mr. NAGLE. If I can have the Chair's indulgence for a moment. What time did the meeting start?

Mr. MYERS. The meeting has been going on for many, many weeks.

Mr. NAGLE. If the meeting has gone on for weeks——

Mr. MYERS. It was delayed on——

Mr. NAGLE. Pardon me, Mr. Myers, I want to form a precise question for you. If the meeting had been going on for many, many weeks and you are telling me there were no major differences, I just don't find that credible. Can I ask you again what were the differences between the DOD and NASA and what was the reconciliation.

Mr. MYERS. The original question was whether the DOD had requirements for the Space Station, in research and whatever, if they could be protected. The answer is we work out with them how that would be done.

Mr. NAGLE. How would that be done?

Mr. MYERS. Actually it turns out that we have separate compartments for activities.

Mr. NAGLE. That took weeks to resolve until 11 o'clock last night?

Mr. MYERS. Let me go on. There was a second issue that actually took quite a lot more detailed negotiation and that had to do with the security issues that might be involved.

Mr. NAGLE. Such as?

Mr. MYERS. Any security issues that are involved in protecting activities associated with the Space Station.

Mr. NAGLE. Give me an example.

Mr. MYERS. Transfer of information, transfer of data, things of that nature.

Mr. NAGLE. What was your position against their request?

Mr. MYERS. It was a matter of working out the details and to explain to them, bring them into what we had done so far in the negotiations and to be sure that we were able to protect their interests and to still be able to have a system that we felt would be acceptable in further negotiations with the Europeans.

Mr. ROE. Will the gentlelady yield?

Mrs. MORELLA. Yes.

Mr. ROE. It seems to me that you are striking on a very important chord here. We talked about, Mr. Walker made the point and it may be critical we just don't know what it is yet, what the optimum cost will be. But it seems to me in your discussions with the Defense Department into the areas did the area of national security come up?

Mr. MYERS. Yes.

Mr. ROE. That is what I wanted to ask. Therefore are we saying that in the Defense Department's interest at this point that there are national security issues involved?

Mr. MYERS. The matter of protecting any national security issues, yes.

Mr. ROE. So, therefore——

Dr. FLETCHER. National security issues of the future. We don't have any national security issues now.

Mr. ROE. No, no, I understand that. We haven't built it yet. I think we ought to clarify for the record that that will probably be reduced to writing, will it not?

Mr. MYERS. Yes.

Mr. ROE. We would like to see a copy of that agreement.

Mr. NAGLE. Mr. Chairman, could I add a request to your request?

Mr. ROE. Sure.

Mr. NAGLE. Dr. Fletcher, did you have interagency memos prior to your meeting in terms of what NASA's position was?

Dr. FLETCHER. We had a well coordinated memorandum of understanding with the Europeans, with our foreign friends, coordinated with the State Department and with the National Security Council, and we thought we had coordinated with the Defense Department

but they had additional issues which I think was more clarification of language.

Mr. NAGLE. I don't mean to be very——

Dr. FLETCHER. They were not issues as much as language clarifications.

Mr. NAGLE. I don't mean to get in the chairman's way but did you have a NASA position paper when you started these negotiations that terminated at 11 o'clock last night?

Dr. FLETCHER. I think we had a national position.

Mr. NAGLE. Did the Defense Department also have its position papers?

Dr. FLETCHER. I think by this time our position paper is their position paper.

Mr. MYERS. It has been coordinated.

Mr. NAGLE. You did not have, your own position in terms of your own interagency memos in what you wanted to accomplish in these negotiations in writing before you went in?

Dr. FLETCHER. Yes, we——

Mr. NAGLE. And they had theirs, is that correct?

Dr. FLETCHER. No, they didn't have their own position, they had comments on ours primarily.

Mr. NAGLE. In addition to showing us the memorandum of agreement could you submit those documents that led to that?

Dr. FLETCHER. To the extent we are able to. I am not so sure about what we are allowed to provide. We have a problem of course with the White House and I am not sure.

Mr. ROE. Understandably so.

Dr. FLETCHER. If it is possible to do so we will.

Mr. ROE. That can come through another direction anyway.

But if the gentlelady will yield further, I think it is important to, in other words, let me ask you this question, in view of those circumstances what proportionate share will the Department of Defense pay for, or is it all prospective?

Dr. FLETCHER. It is all prospective. They have not indicated any requirements for the Space Station. They just wanted to be sure that in the future if they had some requirement that they would not be excluded from the use of the Space Station providing it was for peaceful purposes.

Mr. WALKER. Mr. Chairman, could I ask a question? I am getting adrift and I just want to find out for myself. Under the agreement that you signed would it be possible to do weapons research aboard the station?

Dr. FLETCHER. I think that weapons research in the sense of laser beams or something of that sort, no. But in terms of let's say research on semiconductors which they need to do as well as we, that would be fair game.

Mr. WALKER. Well, my question though is would it be possible to do weapons research aboard the station?

Dr. FLETCHER. Weapons research covers a lot of territory.

Mr. WALKER. I understand that.

Dr. FLETCHER. We are talking about research on components of weapons, the answer is yes.

Mr. WALKER. No, no—OK the answer is yes. Would it be possible to put weapons aboard the station?

Dr. FLETCHER. Nuclear weapons, no absolutely.

Mr. WALKER. I didn't say nuclear. Would it be possible to put weapons of any kind aboard the station under your understanding?

Dr. FLETCHER. I would say possibly knives, something like that, would be a weapon. Weapons is a broad category, Mr. Walker. I hate to be a stinker.

Mr. WALKER. Crowbars and so on fit in, too.

Dr. FLETCHER. A whole weapon? Not the kind that would be used by the Defense Department.

Mr. WALKER. OK.

Is it specifically excluded putting weapons aboard the station under your agreement?

Dr. FLETCHER. Unless it is for peaceful purposes, to that extent it is excluded. Weapons of the kind that I think you are really talking about would be excluded.

Mr. WALKER. We have a Peacekeeper missile. You know, I happen to agree with that, but you know I think we want to know just exactly what it is that that agreement included. Are they specificly excluded from having weapons aboard the station?

Dr. FLETCHER. Mr. Walker let me just say flatly in answer to your question not just exactly but flatly what could not happen. We could not put a major Defense Department weapon on the Space Station and have it acceptable to our European and foreign partners. I will state that flatly. I say major weapons system. That is why I want to get away from knives and things of that sort.

Mr. WALKER. A minor weapons system?

Dr. FLETCHER. Well, how minor. A knife is a minor weapons system.

Mr. WALKER. I think we understand what we are talking about here. We are talking about whether or not the technology of the station could be used in such a way as to present either offensive or defensive capability for this nation.

Dr. FLETCHER. That is extremely unlikely. I don't think our foreign partners would agree to that. I don't think the Defense Department wants that.

Mr. ROE. If the gentlelady will yield, we all got the floor I guess. I think the question is a very, very valid question and in this sense. In all candor and I think that is the purpose of these hearings, we are trying to look over the whole plethora of responsibilities that NASA has at this point. One of the charges that we have assigned our respective committees to look into has to do with the relationship of R&D, both quantitatively and qualitatively in the private sector together with that R&D quantitatively and qualitatively in the Defense, DoD.

Their funds I assure you are like about 50 to 1 as compared to what we are doing in the private sector. One of the issues that is very rapidly emerging is what is our position in space? From NASA's charter which is the peaceful use of space, versus the point of view will the program be skewed so that we are going to be looking further for the military application in space? That is an issue that we have to deal with whether we like it or not. It is there.

Obviously it will be the intent of this committee that that does not get skewed because that is not the charter of NASA in the first place. Therefore, I think it is logical to believe that as far as the

Members are concerned, we are looking at that extremely carefully. Now, there is going to be some overlapping, we understand that but there is very strong feelings on this issue.

I don't think it should be just that our foreign partners, our international partners, partners whether they agree or not. We are still going to have to come up and we are going to have to hopefully if we think it is right to recommend to the Congress that okay on balance we think this is an important thing to do and how much is it going to cost? That is the point the gentleman from Pennsylvania made very eloquently today, whether it is 18, 13—and my God, I don't know what it is going to come out in the press tomorrow—with greatest of respect to the press because we are not sure either—but the fact still remains that here we go into an agreement or an understanding, put it that way, with the Department of Defense and we want to know precisely what that agreement says.

Now, I understand that will go to my question on security issues. That is okay, we can take that up in another body. But it is important for us to know how far that goes because if we join with you in requesting these kinds of fundings that we can represent to the Congress and the different thinking in Congress precisely what that issue is.

Just one more point and forgive me if I am too loquacious, I don't mean to be, the point of weapons, whether it is knives or nuclear weapons is not the issue, the issue is to do they reserve themselves that right to put a weapons system of any kind whatever or does NASA reserve for the peaceful use of space, which is your charter, did you have the right, I don't mean it that way, has that been looked at, is that understood? That is why we want to see what that agreement says.

Dr. FLETCHER. I understand, Mr. Chairman. I think we can give you the sense of the agreement. We may even be able to I am sure in time you will see the agreement that we make with the Europeans but we are in a sensitive negotiation now. But let me answer the only reason that the Defense Department could conceivably want to use the Space Station as it is presently configured is for technology development. R&D. The same things that we are doing in the commercial and science arena.

Mr. ROE. I don't have any fault with that, Doctor.

Dr. FLETCHER. I think the language really reflects that.

Mr. ROE. Or in the antithesis to that should we be considering regardless of what that says to reaffirm in legislative language that it is for the peaceful use of space? That is something the committee will have to decide.

Dr. FLETCHER. Perfectly appropriate, yes.

Mr. ROE. The gentlelady from Maryland.

Mrs. MORELLA. See, Dr. Fletcher, I told you that was a question that could be briefly answered. A final question just having to do with procurement.

I understand that this committee last year did an extensive investigation with regard to cost overruns in the shuttle Centaur program.

Mr. ROE. I just cannot hear. I am getting older and I just cannot hear well any more.

Mrs. MORELLA. Mr. Chairman, you and the committee did an extensive investigation last year on the cost overruns on the shuttle Centaur program and I was curious about the concept of the recommendations for changing, streamlining procurement methods whether or not anything had been done.

I think your recommendation, Mr. Chairman, was that a task force be set up to do that and I know I followed closely what the Defense Department was doing during my campaign in terms of streamlining procurement via the Packard Commission report and the Defense Authorization Bill that did something with that.

Is anything happening in conjunction with your policies?

Dr. FLETCHER. I don't remember the specific recommendations but we are in the process of quote "streamlining our procurement process".

This is per agreement with OMB and I don't know which of us has the responsibility for that. It is in Stu Evans area. Are you current on where we stand there?

Mr. NEWMAN. No, some of the recommendations, the General Phillips report did deal with the procurement process. We do not have at present a separate task force working that problem. We did in fact two or three years ago run through a process of trying to streamline the process and we did have a task force working that problem at that time.

Mrs. MORELLA. Well, if the investigation has been done after the task force that you had, and they looked at cost overruns, even if you don't have a task force perhaps you have further recommendations to follow through. So much money appears to be wasted, not only with cost overruns, but change orders, and just plain cumbersome procurement methods.

I don't know how guilty NASA is. I just know what I have heard. And I am hoping that you will find a remedy—and you may have found one—and that you will show us on the committee what you have done.

Dr. FLETCHER. Mrs. Morella, I think you are right on track. We are the regulatory part of NASA. We do follow the ASPRs of the Defense Department as far as the regulations are concerned. But I think what you are referring to is being sure in the procurement process that we don't have excesses; they don't have these crazy things happening that sometimes happen in other agencies.

One of the recommendations in the Phillips task force was that we tighten up our procurement practices, and maybe that is what you are referring to. That, we are going to do. But I want to quickly say that we don't have as many of those excesses that you find in other parts of government. We have a pretty good procurement system right now, but we are going to make it better. That was one of the recommendations of the Phillips task force.

Mr. ROE. Are there any questions that anyone else would like to ask? If not, we will be submitting questions, Dr. Fletcher, if you would respond to them.

One other thing before you leave. I want to say we thank you for being here. It has been a very productive hearing.

A situation has been called to our attention that has to do with really that the funding will not become available to you until

August, and some of the suppliers, as I understand, are having a problem on trying to hold their human resources together.

Have you looked to that issue? Is there something that can be done there?

Dr. FLETCHER. Mr. Chairman, we have looked intensively at that issue. We are trying to minimize the delay caused by the fact that we are not allowed to spend fiscal year 1987 money until August. But there are ways that we can——

Mr. ROE. I want to know——

Dr. FLETCHER. We can get things started so that delays are minimized. Mr. Newman and Admiral Truly have both been involved. Why don't you start.

Mr. NEWMAN. I would make one point. The money we cannot spend until August is the $2.1 billion that was added. There is not a prohibition against spending some of our fiscal year 1987 basic appropriation for preparation for their production, and we are doing that.

We have programmed about, I think it is $16.5 million, to basically provide some sustaining capability, particularly at the subcontract level, to do some preparation work.

Mr. ROE. If I can offer a suggestion, I think you ought to look at that intensively for the following reason: It seems to me that when we have the particular criticality, supercriticality list now, and the idea of getting ourselves ready to fly in February, if it works out that way, that is really based upon the view, from my point, of quality control particularly; and it seems to me that that is an investment that we could be making, because they are losing some top people, I understand, in different companies simply because they don't have the resources to put up front while they are waiting.

I think that that could be a very, very serious issue that we should look at, particularly if we are going to be concentrating in working with you on that quality control issue. I think it is that important, and it should not slip through the cracks.

If you have a problem on that, let us know. We may have to do some supplemental funding or whatever has to be done, because I think the eye of the storm is going to be, in my judgment, on the NASA organization when we are ready to fly again.

We have to be absolutely positive that everything that we have done or will do, or should be doing, and particularly where quality control is involved, that would concern us. So, if you would take a look at that and let us know so there is nothing that slips through the cracks at that point.

We don't want to come back, God forbid, six months from today saying we should have done this or that. I think it is important, and it ought to be looked at.

If there are no other questions, we thank you very much for a very splendid presentation. We appreciate your being here.

Dr. FLETCHER. Thank you, Mr. Chairman.

[Whereupon, at 12:40 p.m., the committee adjourned, subject to the call of the Chair.]

# 1988 NASA AUTHORIZATION

TUESDAY, FEBRUARY 24, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 9:50 a.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good morning. The meeting will come to order. We are meeting 15 minutes late, but you know what happens through snow and traffic in this particular city.

Today we commence hearings on this 1988 fiscal year budget for NASA. It certainly is a significant fiscal year. It is certainly a significant fiscal year for NASA. The magnitude of recovering from the Challenger accident is now coming into focus, and we expect that this budget will reflect those requirements.

The time for emergency supplemental requests, special budget amendments and other stopgap measures should be behind us. We should now be able to plan for our future space program in a rational manner and budget for this plan accordingly.

Now, the President's request of $9.5 billion is about $1 billion above the baseline of last year. In recent testimony before the Budget Committee, Chairman Roe and I identified a minimum shortfall of $255 million that we think would have resulted from the President's request, and we have recommended a total funding level of $9.736 billion.

While the 1988 request certainly represents a step in the right direction, it falls short of the far-sighted planning that it should represent. There can be no doubt that NASA needs to increase and to diversify our access to space. This doesn't mean that we should push the Shuttle flight schedule past the capabilities of the system. It does mean that we should provide for alternatives such as expendable launch vehicles to build flexibility into the system and to take pressure off of the Shuttle.

The 1988 budget request does not contain any funding for ELVs, and I hope that our witnesses today and in the future can inform us on how we can resolve this problem.

Aside from the direct impacts the Challenger accident has had on NASA, it has also revealed some serious shortcomings in our space program that have been around for some time. It is clear that we failed to properly budget for our planned programs in space research and development. The symptoms of this problem are all too evident.



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Although there is a major increase in the research and development area in the President's request, nevertheless major initiatives such as Mars Observer are being cancelled or delayed. Additional new starts which are ready to begin have not even been proposed.

So, simply put, the NASA budget is and has been inadequate to carry out the space program in the manner expected by the American people and as reflected through the direction by the Congress reflecting the will of the American people. Clearly, it is not in the best interest of this nation to allow this situation to continue to persist.

So you are going to find Chairman Roe and myself pushing vigorously, as we have already tried to articulate to the Budget Committee, for a budget of about $9.75 billion, which includes about another $250 million over and above what the NASA request is. In that, as I have stated, is the fact that we think you ought to have an ELV, preferably a Titan 34D, a Mars Observer, which would allow you to keep the Mars Observer on the 1990 schedule instead of what has been recommended in the budget of delaying it until 1992.

As you know, this committee has felt very strongly about new technologies being developed such as the ACTS program, and over the course of the last couple of years, where NASA, really manacled by the OMB, has had to come forth by terminating that program, this committee has acted in a contrary manner and has kept that particular program alive.

So with that as a preface, we are delighted to have a gentleman who is doing a crackerjack job as the Deputy Administrator, Dale Myers, and accompanied by Mr. Newman, the NASA Comptroller.

We are delighted to have you gentlemen here, and so we will proceed with your testimony after I make note that we will put Bob Walker's statement into the record. He is held up by snow, too. We will put his statement into the record, and then hear from him as he arrives.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS HON. ROBERT S. WALKER - FEBRUARY 24, 1987

I would like to join the Chairman in extending a warm welcome to our witnesses here today. Since this is the first meeting of the Subcommittee on Space Science and Applications in this historic 100th Congress, I would like to take this opportunity to share my view of the authorization process that we are commencing here today.

We on the authorization committees of the Congress serve an important purpose in the budgetary process. I firmly believe that the public is best served when we see this portion of the budget process as an adversarial process in which the administration comes before the Congress with a budget proposal which we then view as something that NASA must defend and support until we are convinced that the program they are proposing represents the best possible use of taxpayer funds.

Those of us who have served on this committee in the past are well aware that for reasons that are beyond NASA's control, this administration has not been at all open in working with the Congress in the establishment of our national space policy. This is not a partisan issue. It is a fundemental Constitutional issue. Under the Constitution the Congress has certain powers which we must guard. In the area of space policy we have had a real issue develop and I want you to know that this Committee, and our counterparts in the other body, are determined to move legislation which will correct these problems.

As we begin this budget process this morning, I want to start by saying that there is considerable good news. The NASA we see today is far removed from the NASA of just one year ago. This is an agency that is recovering confidence

in itself, and with that recovered self-confidence will come renewed public confidence. Two areas of spectacular improvement are the Office of Space Flight and the Safety Reliability and Quality Assurance Office. I want to publicly congratulate all of those concerned in these two areas for a truly remarkable performance in the past year.

I also want to share several concerns that will have to be addressed during this authorization process:

The first of these concerns is that NASA is being perceived as pushing too hard to meet an unrealistic launch date for the next flight. While it is an understandable goal to want to launch as early as possible, I do not, and cannot support rushing through the redesign of the Solid Rocket Booster joint without adequate testing. I am particularly concerned that NASA is saying that you will fly again before the final test firing of QM-8. Despite the fact that this test is the warm weather qualification test, you should not attempt to return to flight status unless, and until, you fully understand that SRB.

My second concern is over the future of the Space Station program. For the past two years this committee has consistantly told you that NASA needs to define a mission for the station and to address the questions of construction and operational costs. In all honesty, I have yet to see sufficient justification to move forward with an $8 billion station. Now we understand that NASA and OMB have agreed that we are no longer even talking about $8 billion. We hear that the number has grown to $14.5 billion, or $15.1 billion if you compare apples and apples, and

that number grows to more than $20 billion, if you count in "real year dollars" which is the only way to count since we will have to pay for it in real year dollars, not 1984 dollars. Space Station is a program in real trouble. We have yet to bend the first piece of metal for the station and the costs have more than doubled. There comes a time when we have to start asking, what are we going to get for this investment, and does it make sense? Is there something else that makes more sense? Can we afford to move forward with a project that is already estimated to cost more than $4 billion a year for the three or four peak construction years within a NASA budget of only $9.5 billion? Unless we can be assured of a major, and long term commitment from OMB to adequately fund this nation's civil space program we, ~~cannot~~ have to question whether we can afford to move forward into a program of this size.

Finally, I want to share a major concern over the health of our space science program. The mission of NASA is to be a cutting edge R&D agency. I am a strong supporter of our manned program. I firmly believe that the destiny of mankind lies beyond the Earth. But, at the same time, we need to ensure that our science programs are supported.

We need a long term national goal, such as a manned mission to Mars, that would have a number of intermediate milestones to measure our progress. Such a program would be a national commitment, with widespread public support, and that widespread support would help to ensure that OMB would have to guarantee adequate resources over the long haul.

Mr. NELSON. Let us start with you, Mr. Myers. Please proceed.

**STATEMENT OF DALE D. MYERS, DEPUTY ADMINISTRATOR, NASA, ACCOMPANIED BY THOMAS C. NEWMAN, COMPTROLLER, AND ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT**

Mr. MYERS. Thank you very much, Mr. Chairman, and members of the subcommittee. It is a real pleasure for me to appear before this committee to represent NASA. It has been a few years since I have been here before. Accompanying me here today is Mr. Newman, the NASA Comptroller, who after my opening statement will give a brief summary of the budget structure and the chronology following my statement.

Dr. Fletcher and I appeared before the full committee a couple of weeks ago and gave an overview of the NASA Fiscal Year 1988 budget request. As most of you were in attendance at that hearing, I will not again review the Fiscal Year 1988 budget request, but instead I would like to concentrate on the progress we have made in strengthening the NASA organization and management and then get back into the budget issues.

For over 25 years NASA has been recognized for its technical and management skills. This combination of skills, accompanied with the achievements in space which the world has still not duplicated, but during its 25-year history NASA has aged—its people, its facilities, and its organization. NASA still has extremely skilled people, exciting programs, and good facilities. But through the loss of some key people, tight budgets, and maybe some unrealistic expectations, NASA was really unprepared for the events of January 28, 1986.

It was in the aftermath of the Challenger accident that NASA, under Dr. Fletcher, set out to strengthen the NASA organization and management, to rectify the problems which had contributed to the accident and organized a management team which would return the program to a safe, sustained space flight and carry the U.S. space program into the future.

Dr. Fletcher established the NASA management study group, under the auspices of the National Academy of Public Administration, directed by General Sam Phillips, to assess NASA's management practices and to evaluate the effectiveness of the NASA organization.

The Phillips NASA management study group made recommendations for strengthening the NASA management in eight areas. Although I have not accomplished all these recommendations, we have in most cases recognized the validity of the work of his group and have initiated the actions which were proposed.

I would like to summarize the status of our progress in each of those eight areas. First, establish strong headquarters program direction for each major NASA program, with clear assignments of responsibility for the NASA centers involved. For the Space Station we established a program management office at NASA headquarters and appointed Tom Moser as the Program Director. His staff, now located in temporary quarters, plans soon to select a permanent location in the Washington metropolitan area. When fully

organized, this organization, the A-prime, will consist of approximately a thousand civil service and supporting contractor personnel for strong systems engineering in the planning and program office. These are the two key offices which we feel are vital to central, strong program management over the various centers involved in the Space Station program.

For the Space Shuttle, we moved the management of the National Space Transportation Systems (NSTS) from the Johnson Space Center, where we had a lead center responsibility, to this same central management operation in Washington, D.C. Arnie Aldridge is Program Director of the NSTS office and is Deputy to Admiral Richard Truly, the Associate Administrator of the Office of Space Flight. Admiral Truly is with me here today.

The complete headquarters NSTS management team has been organized with headquarters personnel, many of whom are colocated at the field centers but answer directly to Admiral Truly through Mr. Aldridge. That means Mr. Aldridge is Program Director, at headquarters. He has program control, systems engineering and integration activities, and has the same backing in the central management of the program that we have for the Space Station.

In the future, we will minimize the multicenter management of programs wherever possible. Where not possible, we will manage them with a strong headquarters office as we have done here with the Space Station and the Shuttle.

The second major area that General Phillips spoke to was to build the discipline and responsiveness to problems into the program management system. As you know, we had some real weaknesses there in the shuttle program, and we focused on this area very strongly.

We are in the process of reinstating the program approval document, or what we call the PAD, which is an agreement between the program manager and the administrator on how the program will be carried out. The PAD gives guidance and milestones which can only be changed with the approval of the administrator. That means there is always a communication link in the system dealing with the major issues of the program. Guidelines for preparing sample PADs are currently being written for the major programs.

We are also implementing a whole set of supporting documentation so that change management can be clearly defined as to the responsibility and authority. I call that the tree of documents. Starting with PAD, the program requirements document relates to the PAD and then other documentation clear down to contractors' specifications all are related into that tree of documentation.

That also defines the change management authority of the various levels of management within the organization and makes it clear when a change must be approved at a higher level. It becomes a very important set of documents for program management.

The PADs and the underlying document will allow NASA management to obtain timely, consistent information. We are taking steps to strengthen our ability to make independent assessments by enhancing the cost-analysis capability of the comptroller's office.

To place the Shuttle and Space Station programs under a single associate administrator, when the administrator is satisfied that re-

covery of the Shuttle will not thereby be compromised. Jim and I decided that it was not yet time to combine the Shuttle and the Space Station. We wanted to be sure that there was no impediment to Admiral Truly's strong emphasis on the actions associated with the Shuttle program. So we do have two separate associate administrators dealing with the Space Station and the Shuttle.

The way we are covering the communication link and the strong interaction between the two programs is that I have a meeting once a month with the two associate administrators to deal with any issues that need direct action concerning the two programs.

Mr. NELSON. Let me ask you right there, why were you considering the combination of the two?

Mr. MYERS. General Phillips felt that there was a tremendous interaction between the Shuttle and the Space Station, being the transportation system for the space station, and because of the interaction between the Shuttle as to integration of payloads into the Shuttle when we launched the Space Station and because of the docking mechanisms. Because of the background of the Shuttle as it relates to the Space Station, he felt that we should at the proper time combine the two programs into one.

We know there are a lot of interactions. At this stage, they are not so large that we cannot handle them by this mechanism of working together between the Associate Administrators and myself. As the program goes forward, I believe we will be using more of the built-in portions of the organizations of the two Space Stations working closely together to tie the two together.

For example, I am going to speak later about our appointment of Bob Aller as head of the Space Operations for NASA, and he is in a planning mode now working on the issues of where will we go in the future as far as the operations end of NASA's programs as we gradually move towards operations again. But in the meantime, of course, many of the operations elements are those that have this strong interaction between the Space Station and the Shuttle and, therefore, Bob Aller becomes a natural place of assignment and delegation from my office as we begin to find more of these elements of interaction between the two programs.

Once we are back to normal Shuttle operations we do intend to put the two programs together. I certainly don't expect that to be until well after the first flight, sometime as we move more from what I consider a strongly R&D-oriented early set of flights on the Shuttle back towards more nearly an operational program.

Incidentally, I probably should say right here that in my eyes, NASA will never have what I consider a straight, clean operational activity as you might see within the military programs, for example. I have worked many programs with the military, and I understand the development of an aircraft and then the transfer to a military operational service. We are really never going to have quite that kind of transfer. I don't think that the Shuttle will ever be a clean, simple, "supply the spares and have someone else operate it" sort of thing. There is an interaction between R&D and operations that will always go on in the Shuttle program. So I don't see that as a clean separation in terms of a transfer of responsibility to an operational group of people like in a Strategic Air Command or something of that sort.

I do see a strong interaction of the operations people as to requirements that deal with ease of operation, the elements that will eventually transfer operational requirements back into the design of devices.

Mr. NELSON. You know, there was a time a couple of years ago, probably as recent as two years ago, that people had notions of fancy that we were going to run the shuttle like an airline. They were even talking about at one point getting some airline companies come in and show us how to run it. That is just not living in the world of the kind of operation that you run when you try to go into space.

Mr. MYERS. The power of the rockets that are involved in the program of this nature convince me that there will always be an amount of tender loving care involved to launch any of these kind of vehicles. Even though we will take advantage of both the military knowledges with respect to how to set up a good spares program, we will work with the airlines as far as the elements that can help us reduce the cost of operations without any impingement on safety. I know Jim Fletcher and I have recognized, that maybe someday, but not for many, many years will this device be like an airline.

Now, on the other hand, I think that all of us recognize there are things that could be done with the design of certain systems of the vehicle, certain of our operational procedures that can give us a sharper definition of the checkout of our devices, a sharper definition of authority and responsibility so that we can save money in the future in these activities.

Right now, of course, we probably have gone the other way. We have put more reviews and more checks and balances into the system. Now we have to work on the other parts of the operation to be sure that we can retain those checks and balances, but continue to work on safely reducing the cost of these operations.

The next item in General Phillips' review was to increase management emphasis on space flight operations, and I have covered that. We have established an Office of Space Flight Operations with Bob Aller as the Associate Administrator. The program combines the previous Office of Tracking and Data Systems with a new activity to plan the consolidation of all space operations within one office. We have not stated when that will occur, but certainly that kind of activity, that shift of operations, certainly will not be done until after we have the Shuttle return to normal operations.

We will place special management emphasis on establishing NASA's world-class leadership in advanced technology in selected areas in both space and aeronautical technology. In the Fiscal Year 1988 budget request we have augmented the space technology program by $70 million for a civil space technology initiative. CSTI, we call it. CSTI will focus on space transportation, launch vehicle propulsion, high-performance engines, and new booster technology and aero-braking.

All these elements of space technology have really been, I wouldn't say lacking, but certainly not emphasized in the last few years. All the activity we have in major engine competence has pretty well been directed at the space shuttle main engine, and even though we do have probably the best competence in large en-

gines in the world, we have really put our emphasis on the shuttle engine and it is time we start to think of the new technologies that will put us in a position for future programs.

CSTI will be implemented in close cooperation with U.S. industry and will help maintain the U.S. competitiveness and leadership in space. We are studying ways to further strengthen R&T capabilities at all NASA facilities and best use the resources by focusing center activities.

The sixth item is to establish a formal planning process within NASA to enunciate long-range goals and to lay out program, institutional, and financial plans for meeting them. I think you will find that NASA is emphasizing more the institutional areas. We are concerned about the future health of the NASA manning of the programs. We feel that there is a need for us to consider the human resources are more strongly than we have in the past, and we are recruiting an assistant deputy administrator for policy to deal with the long-range goals. Later I am going to talk about an associate deputy administrator for institutional areas to deal with the institutional activities. Those two together make up the real strategic and long-range planning for NASA.

We have established a planning staff under Phil Culbertson to support the program and institutional planning processes. We have asked Sally Ride to coordinate a long-range planning activity focused specifically on the mid-1990s. Ms. Ride will report on this activity later this spring.

The seventh item is to strengthen the agencywide leadership in developing and managing people, facilities, and equipment, and other institutional resources. As I said, we are recruiting an assistant deputy administrator for institutions. A major responsibility of this position will be to plan the revitalization of our personnel and our institutional policies.

We have also appointed Ann Bradley to head up our NASA personnel, with her very broad background in the personnel area.

The eighth item is: to improve management of NASA's external relations. We have reorganized our external relations activities under an Office of External Affairs and Relations and an Office of Communications. The Office of External Relations will be responsible for coordinating all external affairs with Congress, industry, foreign, and other Government agencies. Hollister Cantus has been recently appointed to head that office. We are currently recruiting for the position of associate administrator for communications.

Now, where do we stand in all this? The Phillips recommendations ended up with nearly a hundred recommendations. We have formed a program for assignment of responsibility in each of those hundred areas. They are in the process of being worked. We plan to have most of them completed by the end of this year, and the ones that I have described today we have already taken action on.

They are, I think, all directed towards strengthening NASA's management, the definition of responsibility and authority, the areas of long-range planning, and brings in emphasis on specific areas that we probably have not focused on specifically, such as our space technology.

We think it is a tremendous job that General Phillips did for us, and we are going to pay extremely close attention to all the actions

that are involved in that program. Phil Culbertson and our people in the front office are going to assign those responsibilities with Jim's and my approval. We are going to track them on a continuing basis to be sure that they are reacted to strongly and swiftly.

That completes my prepared remarks. I would like now to turn to Mr. Newman, who will give a brief summary of the budget chronology, and following Mr. Newman's remarks we would be glad to answer any questions the subcommittee has, if that is okay with you, Mr. Chairman.

Mr. NELSON. Certainly.

Mr. Newman.

Mr. NEWMAN. Good morning.

Mr. NELSON. Good morning, sir.

Mr. NEWMAN. I think you all have a package here of about 30 pages. I intend to go through the first few pages of that. I think it will give you a compact summary of the budget that we have before you.

On page 2 I have summarized the Fiscal Year 1986, 1987, and 1988 funding by program area. Our figure for Fiscal Year 1987 in the budget is $10.534 billion. Now, that includes the $2.1 billion appropriated to fully fund the replacement orbiter. It also includes $100 million of the amount that was appropriated in Fiscal Year 1986 as a supplemental for the shuttle anomaly resolution activity. $100 million of that becomes available in Fiscal Year 1987, so I have included it in the 1987 column.

For those who are new on the committee, we get our money in four appropriations: research and development—and that includes the more developmental-type activities such as space station, the upper stages of the orbital maneuvering vehicle and space transportation, aeronautics, all the space science activity, the space research and technology.

The program called space flight, control and data communications is basically the shuttle and the tracking and data operations. Construction of facilities is just what it sounds like: the facilities at NASA installations. Research and program management pays all of our civil service salaries, all the travel for civil service, and the basic operations of installations.

Now, as you can see at the bottom, we have now 21,800 people authorized. The budget for Fiscal Year 1988 increases that number by 625 to 22,425.

Mr. NELSON. Mr. Newman, this is an excellent summary, by the way, of laying out on one page. For the new members, would you just give an estimate so that they have an idea of the enormity of the scope? In addition to those 22,000 NASA civil service employees, what would you say would be the full-time equivalent contractor people that are working on NASA programs?

Mr. NEWMAN. We usually do work that out, and the number is around 150,000 in addition to this.

Mr. NELSON. So you are looking at a total of about 170,000–175,000 folks?

Mr. NEWMAN. Something in that range.

Mr. NELSON. All right.

Mr. NEWMAN. When we estimate the jobs generated because of the multiplier effects, we would say the total is about two-and-a-half times that number.

On page 3 and 4 I just thought it appropriate to update you that the 1987 column of this budget is not entirely consistent with the operating plan that we sent to you right after the appropriation took effect. I believe the letter was actually in December. We have made some adjustment to that. We have taken money out of upper-stage because we realized some savings there in addition to what we had projected earlier. We put that money into the advance program to do the joint studies on the heavy-lift vehicle and specifically on the shuttle derived vehicle. We have put money into materials processing, and we augmented the effort on spacelab and space station payload, specifically on payloads to be used on the Space Station.

On the planetary program we have made some adjustments. The decision to delay the Mars observer makes about $20 million available. You can see the augmentation in Galileo and in the Magellan program, and also down below in that item called "Other Space Sciences." We have augmented the planetary research and analysis activity and the work on Mariner Mark 2.

We delayed Scatterometer because of the change in the Navy's plans, and we made $3 million available from that.

The only other change from the operating plan is reflected in the research and program management appropriation where we have a requirement of $41.5 million because of the pay raise that took effect in January and because of our estimate of the effect of the change in the Federal retirement system.

Now, those are incorporated in our Fiscal Year 1988 budget, but of course they occurred after the 1987 budget was approved. So we have those items to cover.

Mr. NELSON. Now, where on these figures are you beginning to shift money so that you can go ahead and stoke up the production on the replacement orbiter? Point that out to us.

Mr. NEWMAN. Well, that was in the basic operating plan as we transmitted it—oh, the money to begin. I am sorry.

Mr. NELSON. Yes. To begin.

Mr. NEWMAN. It was $2.1 billion I was thinking of. The money that is beginning to stoke up that line is in two parts. One part is about $16.5 million, and that is included in shuttle production.

Mr. NELSON. In your initial budget request?

Mr. NEWMAN. Yes. We were planning that in the operating plan. On page 3, right at the top, you see $1.005 billion for shuttle production—did I say page 3? I am sorry. Page 4, at the top of the page.

Mr. NELSON. OK.

Mr. NEWMAN. That 1.005 includes $16.5 million that we had already decided at that time to program into that area, and we are programming that.

In addition, Rockwell is funding about $20 million on their own. So there is about that $36 million going into the pre-production activities.

Mr. MYERS. Could I make a comment there, Mr. Chairman?

Mr. NELSON. Please.

Mr. MYERS. That was really a very vitally important issue because what was happening is we were losing the subcontractors to Rockwell, and we just felt it was extremely important to keep current capable and retain people who could build the parts that then go into the Shuttle. That was why both Rockwell and NASA felt that it was important to get a little bit of money in there during that time period.

Mr. NELSON. What does Rockwell do to protect themselves? Because in essence they are advancing the money here. Is that it?

Mr. MYERS. They are sweating a little.

Mr. NEWMAN. Our agreement with them is that if the program proceeds as planned, that money will be allowable; if it does not, then they will have incurred a cost.

Mr. NELSON. But in your budgetary manipulations, you have come up with $16.5 million?

Mr. NEWMAN. That's correct.

Mr. NELSON. Which basically will carry you through to the August 1st release date?

Mr. NEWMAN. Yes.

Mr. NELSON. And at that point you have the full authorization of $2.1 billion?

Mr. MYERS. Yes, we do.

Mr. NELSON. All right.

Mr. NEWMAN. That's right. But, of course, we will preserve that in a way to cover the obligation requirements over the next four years, basically, until the orbiter is completed.

Mr. NELSON. All right.

Mr. NEWMAN. Page 5 is one I hesitated to put in, but staff asked me to try to explain all the adjustments that occurred since last year to this year, to give you a history of the 1987 budget. I will try to do that in as simple a form as I can.

In January a year ago, before the accident and after the Gramm-Rudman adjustments, you can see that we had $7.333 billion in Fiscal Year 1986 and $7.694 billion in Fiscal Year 1987. Now, with the accident there were a lot of changes, a lot of increases and a lot of decreases that we had to cover. There were savings by reduction of our plan in shuttle operations, by reductions in our activities for things like operation of space telescopes that we had been planning to cover in 1987. There were a number of reductions, and you can see the figures we estimated there.

But there were also a lot of things that we had to cover. The biggest single one was the loss of reimbursements that we had anticipated in the Shuttle. The Shuttle budget is keyed to both funding by NASA and by reimbursable users, and when those reimbursements did not materialize, we had to figure out how to cover off against the net effect of the lost reimbursements as against the savings in Shuttle operations. We also had to provide for the replacement of the tracking and data relay satellite.

When you take all those adjustments into account, we identified about $56 million in Fiscal Year 1986 and about $45 million in Fiscal Year 1987 that we could at that point apply to get started on the salvage operation, the investigations really to determine what could be done at that point, and initially to start the fix that we knew we had to on the solid rocket booster.

In May the Congress helped us out greatly by approving the supplemental appropriation. The total appropriation was $531 million. $5 million of that was for automation and robotics, and $526 million available for Shuttle. But $100 million of that was to be made available in 1987 and $426 million in Fiscal Year 1986. So, those amounts were added to our base.

Then came the budget amendment in August. Now, the budget amendment proposed to add $250 million for the orbiter to start. It included $36 million to proceed with procurement of replacement airborne support equipment for the interim upper stage that we lost in the accident. We included $94 million that we would program—in effect, reprogram—into the anomaly resolution activities because at that time we had just received the Rogers Commission report. There were a number of additional requirements identified in that report that had not been in our earlier plans.

We identified $108 million of offsetting reductions in other areas, and all that led to a net budget amendment of $272 million. So, at that point we had in Fiscal Year 1986 still the $7.764 billion, and the Fiscal Year 1987 $8.006 billion.

Now, congressional action on that fully funded the orbiter, so instead of $250 million, as proposed, we got an additional $1.850 billion, to bring that total to $2.1 billion.

Because of the discussions with regard to the Department of Defense reimbursements in all that activity, Congress helped us out a great deal by appropriating the money that would have been appropriated to DOD directly to NASA, and that is the $531 million.

There was also provision for conducting the ACTS mission and $77 million was added for that, and there were a series of other changes which netted out to $10 million. Some augmentation in science and a few reductions.

So, anyway, the total result of that is the $10.535 billion that is in our budget now. Within that amount I wanted to show the amounts we have provided for the shuttle anomaly resolution and Rogers Commission activities. The total available between the two years if the $493 million shown in 1986 plus the $282 million in 1987.

But because of the phasing, we are applying about $300 million of that 1986 amount in 1987, so down at the bottom of the page you see the amount that we are in fact making available for the anomaly resolution activities, for the additional things that we think need to be done to comply with the Rogers Commission. You can also see the amount that is available for those activities in 1988 as well as those years. Now, those amounts are all included in the budget, as we have laid it out before you.

Mr. NELSON. All right. Mr. Newman, that is excellent, and we appreciate it.

Now, if it is okay with the members, as a courtesy to Admiral Truly, who needs to run on to a meeting, we want him to come up to the table and ask him one or two questions here and then have any of you follow up with any questions you have of Admiral Truly and then we will let him go and then we will continue with you, Mr. Myers and Mr. Newman.

Admiral TRULY. Good morning.

Mr. NELSON. We understand that Morton-Thiokol carried out two tests yesterday, Admiral Truly, on the SRB joints, which was to try to duplicate the SRB joint failure as it occurred on Flight 51-L. Can you enlighten us on these tests, please?

Admiral TRULY. Perhaps it is the way we described the tests. I am familiar with one major test that we ran yesterday that had two major objectives. If I am incorrect, I can get better information to you.

We have a joint environment simulator out at Morton-Thiokol that is full-scale in diameter but it is a short stack. It is essentially three cylindrical case segments rather than the total 5½ case segments on a normal solid rocket motor. We have run a number of tests in this facility in the past five or six months, and we ran one yesterday. And these were using the 51-L steel hardware that we had at the time of the accident. Just to get ahead of myself a little bit, the remaining tests will be with our new design.

The test that was run yesterday tested O-ring materials that had a preplanned—in other words, we drilled a little hole and created a potential leak path—to force hot gases from the propellants to the material. The test did run on schedule. We intend to pare down the segments and look at the materials.

The initial information that I had this morning was that the test went on schedule, as I said, and apparently was successful. In one of the little holes that we drilled at one of the case segments we did see on the instrumentation a slight amount of pressure that would tend to make you think that in fact we did blow-by hot gases past the first O-ring but not the second one. We will have to take the hardware apart to totally confirm that.

In the second of the two objectives of that test, apparently there was no pressure rise. It was an instrumented test. There was no pressure rise between the two O-rings, and so we did not violate it.

One of our earlier tests that was chilled—and I am not sure on yesterday's test what temperature it was chilled to; I have that information if you would like it—but we did run a previous test on this same facility several months ago and essentially did duplicate the 51-L occurrence at liftoff where we blew smoke all the way past the two O-rings.

Mr. NELSON. All right. Now, your full-up test of your redesign is coming, if I recall, I think Rick Houck told me he thought it is about March 25. Is that still on schedule?

Admiral TRULY. March 25 is the schedule for our first full-scale motor firing. However, it is not of the new design. It has some new insulation and adhesives in it. However, we call it an engineering test motor. It is the only full-scale test that we will fire with the 51-L design case hardware. All tests, all full-scale tests, after the March 25th one will be of the redesigned solid rocket motor.

Mr. NELSON. Do you have any idea, just approximate, when you would have your full-up test firing of your redesigned hardware?

Admiral TRULY. I can check here in 30 seconds, I think, and pull that out. If I remember right, it's late June is the schedule for the first test. But I will look at that for you.

Mr. NELSON. Okay. So, the March 25th is taking the old hardware, but not in the same configuration that it was on 51-L?

Admiral TRULY. Again, I would have to get you the specific details. The steel, the case segment itself, is identical to 51–L. However, in each of the joints, we are, for example, using different O-ring materials in some of the joints; we are using different insulation between the propellant segments' insulation techniques. It is going to be fully instrumented so we can get a leg up on some of the design problems in the motor, but not the steel case hardware.

Mr. NELSON. OK. Now, you know that the NRC has said that NASA ought to be able to predict the test results. Okay. Now, were you able to predict, in fact, what happened yesterday in your test?

Admiral TRULY. I am not sure, and as a matter of fact, I asked that question this morning of some of my people, and I want to make sure. We had a management council last Friday, and at that time I asked what was predicted with regard to the O-ring damage that we expected to see in this test yesterday. I was told that we expected to see about 50 thousandths erosion at the point where the hole was drilled and the hot gases would see the O-ring. Until we break down the motor and take a look, we really won't know.

But we are quite aware and working with the NRC oversight committee. We agree that for each of our major tests we should predict the results through analysis, and then after the test, compared to the prediction—it doesn't mean, incidentally, that each test will go as predicted. I am sure that we will learn things as we go; that's why we're doing it. But we are trying to predict results, and we will compare each of the major tests.

Mr. NELSON. Well, assuming, when you break down the motor, you find that it operated exactly as you had predicted on this test yesterday, what has changed in the operation that allows you to predict with accuracy now as opposed to prior to Challenger that did not allow us to predict there?

Admiral TRULY. I think that as the investigation showed, frankly the design, as we've said before, the design just was not well understood. We did not do the correct amount of testing on that joint design that we did even in the early months after the investigation. We now do understand the performance of the old design.

We have used that knowledge in several ways, but most importantly to predict performance of the redesigned joint, and that is the reason we are doing what we just discussed with your previous question; and that is, try to refine our analysis techniques and then duplicate them with tests, which gives you great confidence in your knowledge of the design.

Mr. NELSON. Admiral, are you convinced now that we understand the behavior of these joints and the O-rings so that we really do know what goes on in that joint, or are we still trying to guess what is going to be happening?

Admiral TRULY. I am assuming you are asking about the 51–L joint failure.

Mr. NELSON. Yes, sir.

Admiral TRULY. I believe that we do understand what happened. I do think that we have already demonstrated in our previous tests—and I can't speak for yesterday's because we haven't torn it down yet—that we were able to predict results. We have had good success in the predictions. I don't think, as I said before, that the

design was fully understood at the time of the failure, but I do think we understand it now.

Mr. NELSON. Okay. As part of the oversight of this committee, what we would like so that we can doublecheck to make sure that you are proceeding in the way that you want to proceed, let's have you submit to the committee in writing your prediction for the March 25th test. Then we will be able to, after the test, when you break down the motor and see how it is, what the results are, we will be able to compare.

Admiral TRULY. We would be pleased to do that before the test. I should tell you that this is a dynamic program and there are a lot of days between now and March 25, and I am sure that our actual technical predictions will be finalized quite close to the test date.

Mr. NELSON. OK.

Before Admiral Truly runs on to his meeting, are there any questions from the committee of Admiral Truly? Yes, Mr. Packard.

Mr. PACKARD. Mr. Chairman, if I could.

In the Rogers Commission there were several anomalies outlined, and I believe that on your budget proposal here there is included a certain budget amount for the correction of these anomalies.

Do these budget amounts correspond to all of the anomalies, or are there any anomalies left out that are not planned to be corrected before the next launch?

Admiral TRULY. I am not considering that we have any constraint from a budget point of view in correcting needed anomalies to make the system safe to fly. We are actively managing the anomaly funding that has been given us, and there are threats to that as the days go on and we continue. As you realize, we are still in the process of analyzing systems and making decisions. So, it is an active conversation between myself and the program and Mr. Newman and the Deputy Administrator as to the management of the funds. However, there are no anomalies that we are not doing because of lack of funding.

Mr. PACKARD. Are there anomalies that, by policy decision, will not be corrected or are not planned to be corrected before the next launch? If so, which are they?

Admiral TRULY. No. We have a complex system to evaluate both the solid rocket motor failure and the other——

Mr. PACKARD. Let me list some of the anomalies that come to my mind, although it may not be all of them.

Admiral TRULY. Okay. Sure.

Mr. PACKARD. You mentioned and referred to the solid rocket motors and the anomalies that we have experienced over the years in that.

Admiral TRULY. Yes, sir.

Mr. PACKARD. Those are planned to be corrected?

Admiral TRULY. That's correct.

Mr. PACKARD. Before the next launch?

Admiral TRULY. That's correct, including other changes in the motor such as the changes in the nozzle of anomalous performance that we had seen prior to the flight. We are taking this downtime opportunity to correct things like that.

Mr. PACKARD. Brakes and landing gear?

Admiral TRULY. Yes, sir.

Mr. PACKARD. Those are? And of course, the O-rings. And escape facilities, even though that was not listed as an anomaly, it certainly is an area to be touched.

Admiral TRULY. It is an area that we have studied. We have made one, I think, significant decision in the escape area, which is pyrotechnically removable hatch, which would be useful in a very limited area in stable gliding flight for escape from the orbiter, but I think more importantly provides a fast exit from the orbiter for an unforeseen contingency on the runway, a landing incident. And for a system, I think, that is going to be flying for the next 20 or 25 years, we felt that that was prudent to do. So, we are taking action in that area.

Mr. PACKARD. The last point is, to your understanding, to correct all of these anomalies that we have talked about plus others that we may not recall, budget funds are adequate to cover those corrections?

Admiral TRULY. Our projections today say that they are. I must tell you that I am concerned about threats that we see in the system, but we are actively working those as we go along. And if it turns out that I feel that I cannot manage the anomaly correction within the funds that I have available, I am going to be the first to raise my hand and bring the subject up.

Mr. PACKARD. And the organizational and communication problems that were addressed in the Rogers Commission, there are budget proposals to adequately correct those problems?

Mr. NEWMAN. I wonder if I could add that as far as we can tell, we have in fact covered everything that has been identified in the Rogers Commission and the anomaly resolution investigations of our own.

There is one thing I would say. Many of the Rogers Commission recommendations really had to do with preparing yourself to sustain a flight rate rather than what you needed to do in order to have the initial flight. So, there is funding, in fact, after Fiscal Year 1988, after we have actually flown, to do things that will permit you to sustain a flight rate.

Mr. MYERS. Such as adequate spares, for example.

Mr. PACKARD. And that would be an ongoing requirement.

Thank you, Mr. Chairman.

Thank you, Admiral.

Mr. NELSON. Those are good questions, Mr. Packard.

Thank you for providing that information.

Admiral TRULY. Thank you, Mr. Chairman.

Mr. NELSON. All right. Now for Mr. Myers and Mr. Newman, let me call on the members.

Mr. Brown.

Mr. BROWN. Gentlemen, I think that one of the items of information that the subcommittee will want is what kind of numbers did you submit to OMB and where are the differences between the numbers that you submitted and what we are getting from OMB; for example, on the ACTS program, on expendable launch vehicles, on various other things where there was disagreement? Now, you don't have to discuss all those orally, but for the record I would like a complete submission, if you could.

[Information to be furnished follows:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1988 BUDGET

| | FY 1987 CONG BUDGET | FY 1988 ONB BUDGET | △ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| RESEARCH AND DEVELOPMENT | 3127.7 | 4106.4 | -483.2 | 3623.2 | |
| Space Station | 420.0 | 1055.0 | -288.0 | 767.0 | Reduction consistent with early development schedule changes. |
| Space Transportation Capability Development | 495.5 | 570.4 | -1.8 | 568.6 | Adjustment to payload operations funding. |
| Space Science and Applications | 1552.6 | 1616.7 | -108.4 | 1508.3 | |
| Space Science | 983.4 | 987.4 | -38.4 | 949.0 | |
| Physics and Astronomy | 552.8 | 605.5 | -38.4 | 567.1 | |
| Hubble Space Telescope Development | 101.3 | 98.4 | 0.0 | 98.4 | |
| Gamma Ray Observatory Development | 58.5 | 49.1 | 0.0 | 49.1 | |
| Spacelab P/L Dev. & Mission Mgmt. | 98.1 | 96.8 | -1.4 | 95.4 | Adjustment to shuttle payload funding. |
| High Resolution Solar Obs Dev | 0.0 | 12.0 | -12.0 | 0.0 | Deletion of funds for proposed new initative. |
| Explorer Development | 56.7 | 60.3 | 0.0 | 60.3 | |
| Mission Ops & Data Analysis | 125.7 | 128.1 | 0.0 | 128.1 | |
| Research and Analysis | 53.4 | 85.1 | -25.0 | 60.1 | Deletion of $25.0M for AXAF Pathfind. ATD. |
| Suborbital Program | 75.1 | 75.7 | 0.0 | 75.7 | |
| Life Sciences | 72.2 | 74.6 | 0.0 | 74.6 | |
| Life Sciences Flight Experiments | 30.4 | 32.9 | 0.0 | 32.9 | |
| Research and Analysis | 41.8 | 41.7 | 0.0 | 41.7 | |
| Planetary Exploration | 358.4 | 307.3 | 0.0 | 307.3 | |
| Galileo Development | 71.2 | 55.3 | 0.0 | 55.3 | |
| Ulysses | 10.3 | 10.8 | 0.0 | 10.8 | |
| Magellan | 92.6 | 59.6 | 0.0 | 59.6 | |
| Mars Observer | 35.8 | 29.3 | 0.0 | 29.3 | |
| Mission Ops. & Data Analysis | 80.0 | 77.0 | 0.0 | 77.0 | |
| Research and Analysis | 68.5 | 75.3 | 0.0 | 75.3 | |

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | △ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| Space Applications | 569.2 | 629.3 | -70.0 | 559.3 | |
| Solid Earth Observations | 75.6 | 76.8 | 0.0 | 76.8 | |
| Shuttle/Spacelab Payload Development | 21.6 | 21.1 | 0.0 | 21.1 | |
| Applied Research, Data Anaysis and Related Activities | 54.0 | 55.7 | 0.0 | 55.7 | |
| Environmental Observations | 320.9 | 393.8 | 0.0 | 393.8 | |
| Upper Atmospheric Research Satellite | 114.2 | 95.4 | 0.0 | 95.4 | |
| Shuttle/Spacelab Payload Development | 12.0 | 19.4 | 0.0 | 19.4 | |
| Applied Research, Data Analysis and Related Activities | 142.8 | 141.3 | 0.0 | 141.3 | |
| Scatterometer | 32.9 | 22.7 | 0.0 | 22.7 | |
| Ocean Topography Experiment | 19.0 | 90.0 | 0.0 | 90.0 | |
| Global Geospace Science | 0.0 | 25.0 | 0.0 | 25.0 | |
| Materials Processing | 47.9 | 45.9 | 0.0 | 45.9 | |
| Space Communication | 103.5 | 90.5 | -70.0 | 20.5 | |
| Search and Rescue Transition | 1.0 | 1.3 | 0.0 | 1.3 | |
| Adv. Comm. Tech. Satellite Development | 85.0 | 70.0 | -70.0 | 0.0 | Consistent with FY 1987 rescission. |
| Applied Research, Data Analysis and Related Activities | 17.5 | 19.2 | 0.0 | 19.2 | |
| Information Systems | 21.3 | 22.3 | 0.0 | 22.3 | |
| Commercial Programs | 41.3 | 54.0 | 0.0 | 54.0 | |
| Technology Utilization | 15.7 | 18.3 | 0.0 | 18.3 | |
| Commercial Use of Space | 25.6 | 35.7 | 0.0 | 35.7 | |
| Aeronautical Research and Technology | 376.0 | 385.0 | -10.0 | 375.0 | |
| Research and Technology Base | 272.9 | 285.2 | 0.0 | 285.2 | |
| Systems Technology Programs | 103.1 | 99.8 | -10.0 | 89.8 | Deletion of funds for High Alpha Technology. |
| Transatmospheric Research and Technology | 45.0 | 66.0 | 0.0 | 66.0 | |

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | Δ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| Space Research and Technology | 171.0 | 325.0 | -75.0 | 250.0 | |
| Research and Technology Base | 133.6 | 115.9 | 0.0 | 115.9 | Reduction of funds for CSTI program. |
| Systems Tech Program | 37.4 | -- | -- | -- | |
| CSTI Program | -- | 154.1 | -20.0 | 134.1 | |
| Pathfinder | -- | 55.0 | -55.0 | 0.0 | Deletion of augmentation directed at enabling technology for future missions. |
| Safety, Reliability and Quality Assurance | 9.2 | 16.2 | 0.0 | 16.2 | |
| Tracking and Data Acquisition Advanced Sys | 17.1 | 18.1 | 0.0 | 18.1 | |
| SPACE FLIGHT, CONTROL, AND DATA COMMUNICATION | 5815.0 | 4064.3 | 0.0 | 4064.3 | |
| Shuttle Production & Capability Development | 1005.1 | 1229.6 | 0.0 | 1229.6 | |
| Replacement Orbiter | 2100.0 | -- | -- | -- | |
| Space Shuttle Operations | 1847.0 | 1885.8 | 0.0 | 1885.8 | |
| Space and Ground Networks, Communications and Data Systems | 862.9 | 948.9 | 0.0 | 948.9 | |
| RESEARCH AND PROGRAM MANAGEMENT | 1425.0 | 1634.0 | -36.0 | 1598.0 | -30.0M for new initiatives and augmentations, -5.0M reestimate of FERS. |
| CONSTRUCTION OF FACILITIES | 166.3 | 219.6 | -24.1 | 195.5 | -17.8M for Large Spacecraft Lab at LaRC; -6.3M for Mods to Atmospheric Reentry Materials and Structures Evaluation Fac at JSC. |
| TOTAL NASA | 10534.0 | 10824.3 | -543.3 | 9481.0 | |

Mr. NEWMAN. We will provide the detail. But just a quick answer, Mr. Brown, we requested originally $10.5 billion. When we adjusted for the orbiter that we originally thought we needed to fund in 1987 was fully funded, and we adjusted for the pathfinder program and the pay raise, then our resultant figure was just over $10 billion, $10.024 billion. The allowance is $9.5 billion, so the reduction was $543 million.

Mr. BROWN. You were really treated fairly reasonably.

Mr. NEWMAN. Overall we think so.

Mr. MYERS. We think we were.

Mr. BROWN. But I would still like to reiterate and emphasize what the chairman said initially, that in a number of areas, including the two that I have mentioned, there is a historic difference between the committee and OMB, and it is my very strong feeling which I will propound on a number of occasions, that the level that the chairman has suggested is a bare minimum to maintain the aggressive, vigorous program that the Congress would like to see.

Mr. MYERS. Mr. Brown, concerning the expendable launch vehicles, we have in NASA recognized a tremendous damage that we have done to the science programs of this country because of the delay in the shuttle launch capability, and have initiated a very thorough study of the best way to at least help ourselves with respect to launching vehicles, launching some of these payloads that are backlogged.

The ELVs were not in our request for 1988 because we really just hadn't gotten our act together on that. We had paid so much attention to getting the shuttle back in business that we had not yet totally focused on the ELV issue, and we now feel that there are certainly some requirements and we are working inside the administration to see what we can do about that.

Mr. BROWN. Well, it would be our hope that you move expeditiously. It is the ELV situation, for example, that may be the factor that is delaying the Mars observer.

Mr. MYERS. We have suggested that if we could make available a Titan 34D, we could launch the Mars observer on schedule in 1990.

Mr. BROWN. Well, it would make a great number of us happy here in the committee if you could come to that conclusion.

Mr. MYERS. We are certainly looking very aggressively at that.

Mr. BROWN. And we still are going to have to fight with Mr. Boland over it, so the sooner you can act on it, the better off we are going to be.

I have no further questions, Mr. Chairman.

Mr. NELSON. You know, it's interesting with regard to those ELVs, if as a result of the accident, if you take into account all the payloads that NASA has to put up and then how much capacity they are going to have in the shuttle, assuming that we get the shuttle starting to fly in early 1988, and if you assume a shuttle flight rate for, say, being conservative and say 12 a year, and you look at all the payloads that are sitting around in the warehouse and the other payloads that you need to fly up through 1995, and the figure is an astounding figure over and above our shuttle capacity, even bringing on the new orbiter, an astounding 50 equivalent cargo bay loads of payloads to get up in space.

Now, if you figure, just take rough mathematics, that that is equivalent to more than two payloads, two ELV equivalents per shuttle cargo bay payload, then you are looking at in the range of something like 125 ELVs that have not been provided as a startup in this budget, 125 ELV launches over and above the capability of the space shuttle between 1988 and 1995.

So, you know, I think that underscores the fact of the deficiency in this budget as you have come forth. I mean, we are not going to sit around as the United States of America and let all those payloads stay on the shelf. We are going to have to get them up there one way or another.

Mr. BROWN. Mr. Chairman.

Mr. NELSON. Yes, indeed.

Mr. BROWN. May I have one further question?

Mr. NELSON. Certainly.

Mr. BROWN. I meant to inquire about the effort that you are making with regard to responding to the committee's request for an analysis of what NASA can do about the commission's report on future goals. Is that what Sally Ride is working on basically?

Mr. MYERS. Yes, it is, Mr. Brown. She has been active in that for several months now and working with our advanced-design people in transportation, with our advanced-design people in science and in technology. These ideas are very broadly coordinated with other elements of the Government, and those ideas are coming into focus in the March-April time period.

Mr. BROWN. That is, you are expecting to be able to present a report to the Congress in that time frame?

Mr. MYERS. We will have a report complete, ready for our review within the administration at that time. I can't give you an answer on when it will be presented to Congress. There may be some iteration of that.

Mr. BROWN. My recollection is that we wanted to have something around March. Is that what we have in the legislation on the futures report? Of course, the legislation didn't pass.

Mr. NELSON. Yes. Well, it passed; it was just vetoed. But nevertheless——

Mr. BROWN. Maybe because of that.

Mr. NELSON. No. But the policy guidelines are there. My recollection of the bill is that it's something like March.

Mr. BROWN. Well, I would just like to stress—and I noted while you were commenting on the Phillips report with regard to the management changes—there is no management change as effective in securing the optimum operation of an organization as in knowing clearly where it's going, and that means having enunciated an approved set of goals that have the support of both the Congress and the executive branch. You would do more to improve the management at NASA, it seems to me, if you can move that along.

Of course, there are certain intangibles such as aggressive leadership that are required in order to accomplish these kinds of goals. But I would encourage you to move as quickly as possible to get something before us in that regard.

Mr. MYERS. Mr. Brown, I am sorry if I didn't give you a strong enough impression of our interest in this area. Jim Fletcher has had that aggressive interest in developing these goals for NASA,

the vision of where NASA is going, before I came here. He has continued to press in that area.

The Phillips recommendations dwelled quite strongly on this issue of visions and on the process, and we have set up that process by specifically defining our long-range planning and our strategic planning activities with a strong emphasis with Phil Culbertson in his new role, focusing in this area and focusing the system to respond to that activity.

I think if you saw within NASA what was going on, you would see a very aggressive activity on the part of Jim Fletcher to get this established and to lead us through the administration and Congress.

Mr. BROWN. Well, I am sure that you are aware that it is not our desire to place any blame or fault-finding with NASA, because we recognize the good work that Mr. Fletcher has done, and others in NASA. Within this complicated system that we live in, there are many players, and we have got to get them all into line, and this is what we are anxious to do.

Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Brown.

Mr. Slaughter?

Mr. SLAUGHTER. Thank you, Mr. Chairman.

Mr. Newman, what did you say the amount was that you needed?

Mr. NEWMAN. The amount we would need to allocate is not in the Fiscal Year 1987 plan. It is about $16–$18 million. The amount that we would need in Fiscal Year 1988 is about $50–$55 million, to accelerate from the 1992 plan to the 1990 plan. That is for the spacecraft; that does not include the launch vehicle.

Mr. NELSON. And then the chairman's recommendation to you, when we get around to mark-up at the latter part of March, it will have that recommendation in it.

Mr. NEWMAN. May I add one point?

Mr. NELSON. Sure.

Mr. NEWMAN. That is not a net increase that we would actually save in total. It would offset money that would have to otherwise be budgeted in the future.

Mr. MYERS. You see, the problem is we were in a position where the Mars Observer would be launched in 1992, and by pulling it back to 1990, we actually save money in those future years.

Mr. BUECHNER. Mr. Myers, back in August Mr. Daniel Fink from the advisory council sent a rather scathing letter—I guess that is maybe not the right word—but pointed letter to Dr. Fletcher. At the same time, was there a printed response to that letter? Has the agency come up with a general printed rejoinder?

Mr. MYERS. I know that we always respond to the NAC. I am not sure. Let me check and for the record give you an answer on that. I believe we did answer the letter.

Mr. BUECHNER. If there is, could you provide a copy to myself and to any other members of the committee that would like one?

Mr. MYERS. Yes, sir.

[The letter mentioned above follows:]

Attached is a response to Dan Fink's letter of August 14, 1986, to Jim Fletcher.

AUG 26 1986

Mr. Daniel J. Fink, Chairman
NASA Advisory Council
Code LB
National Aeronautics and
Space Administration
Washington, DC 20546

Dear Dan:

Your NASA Advisory Council report of August 14, 1986, is a great service to NASA and the nation. You have pinpointed a key problem, the erosion of our capability to lead the world in aerospace technology; you have accurately identified the elements of recovery, clear long-range goals supported by adequate resources. You know that I did not return to NASA to preside over its decline to second class status in the hierarchy of spacefaring nations. It is my intent to see that our launch capability is rebuilt, that we restock our reservoirs of advanced space technology, and that we use those capabilities to return to the forefront of human space activity. I take your statement to heart because it reflects my intention to move ahead. Your continuing counsel will help "keep our feet to the fire."

You know we cannot respond in specific terms to the detailed program recommendations you offered while our budget submission is being considered by the Administration for submission to the Congress this winter, but you can be assured that your excellent program recommendations are being fully considered by NASA as we develop the Fiscal Year 1988 budget proposal. Adequate funding to support the first class program that is our mandate can only be provided as a result of a national commitment well beyond the limits to NASA's authority. All of us, both inside and outside government, must work to achieve that commitment.

You also state that the Council is concerned about the pace at which the nation has moved to recover from the loss of the Challenger and its crew. While that pace has appeared to be unduly slow, NASA has had to determine and fully understand the reasons for the accident, initiate actions to prevent any recurrence, and establish the basis for a mixed fleet, including appropriate expendable launch vehicles, all while striving to meet stringent national budgetary constraints. President Reagan has now approved procurement of an orbiter to replace the

Challenger and we will initiate that procurement in Fiscal Year 1987. I intend to request funds to complete the orbiter in subsequent years while at the same time maintaining the forward momentum of our science, technology, and applications programs and developing the Space Station. I believe that these actions will go a long way towards restoring the Nation's space capability.

In closing, I want to thank you and the Council for your thoughtful assessment of NASA's and the Nation's choices; I assure you we are striving hard to make the right ones.

Sincerely,

Original Signed by
James C. Fletcher

James C. Fletcher
Administrator

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Mr. BUECHNER. In that there was, I guess, a general trend that said that the entire space program, especially in terms of where we are going to be for the future, that the United States has severely been eroded in its leadership position, and then they went at some particular areas. If you would like to make any comments now, that would be fine. What are your general feelings about what has happened in the last seven months?

Mr. MYERS. Well, we generally agreed with Dan Fink's comments. They were made up from a very notable group of people that are on our NASA advisory council, including me before I came to NASA, and we were all concerned about where NASA was going in the future.

One of the things that is in this budget is an important part of that, to me, and that is the program called CSTI. It is the space technology initiative that we have for beginning to work space technology in more like we have always worked aeronautics. I think NASA has a tremendous reputation in their aeronautics program in doing advanced research of their own and also working closely with industry. I think it is part of why our Nation has its strongest balance of trade in the right direction through its aircraft program. NASA, and NACA before it, have been very important to that.

We want to get ourselves in the same position in space technology, not just aeronautic technology, and that was one of the things Dan was talking about. We have taken that action in this budget.

The other thing that he was concerned about, at least as I remember that letter, was this same point of the long range, the vision of where NASA is headed, where the United States should be in their civil space program. Our activities that are under way now I think will respond strongly to that, and certainly in that activity Jim Fletcher is playing a very strong role.

But we will get our answer to that letter to you, and we will respond in the spring with our new initiatives.

Incidentally, I might add that this weekend NASA is having a strategic planning conference where we bring together all our center directors and our senior people and are reviewing with Ms. Ride and others the status of where all these various possibilities of initiatives can be reviewed in an offsite meeting that we are going to have. So we are really serious about this.

Mr. BUECHNER. Well, Mr. Myers, I think you can see, looking up here, that you have a lot of new faces. There are a lot of freshman members on this subcommittee, and I know that we hope that we will be here to watch you get back in taking an assertive lead. Any kind of information that you can provide us with, since we have not been here before, I know we will appreciate. Thank you.

Mr. MYERS. Very good. Thank you.

Mr. NELSON. Before I call on Mr. Packard, let me remind the members that we are going to have an organizational look-at-the-schedule kind of meeting this afternoon at 3:00, and it will be right in this room. So if you could be here, Mr. Buechner will address directly some of the questions.

It is going to be in the big committee room instead of this one.

Mr. Packard?

Mr. PACKARD. Thank you, Mr. Chairman.

I would like to pursue a little bit further the ELVs and our plans there. How long do you estimate, Mr. Myers, it will take to develop a policy and a schedule and a budget for ELV operation?

Mr. MYERS. Mr. Packard, we have put together, I think, a good plan as to what we believe are the sort of minimum ELV programs that would take us across a period up through 1992. The reason we break at 1992 is that there is a new world that could come into being beyond 1992. That is the question of wither goest the heavy-lift launch vehicle?

If a shuttle-derived vehicle, for example, were to come in in the 1993 time period, it would make a tremendous difference in this big bunch of backlogged payloads that are involved and would be involved perhaps in the assembly of the Space Station, which in turn would make the Shuttle more available for other launches of other payloads.

Now, I made that kind of a long story there. The short end of it, the part from here to 1992, we have, I think, a well-considered approach to the heavy-lift launch—excuse me, the expendable launch vehicle activities up through 1992. We have it now as one of our budget threats. We are discussing it along with the issues associated with the cost of the Space Station with the OMB, and with other threats to our budget, such as new initiatives. I really am not in a position to give you an answer as to when we will have a direct answer to that question.

Mr. PACKARD. In your preliminary evaluation and development of your policy and schedule and budget for the expendable launch vehicles, are you anticipating any payload launch on ELVs during the 1987 budget year? And again in the 1988 budget year, I would be interested.

Mr. MYERS. There are 1987 launches, but they are all cases where we act as the agent for other groups. For example, we launch NOAA's satellites and we have one now on the launchpad. You may have read about it in the paper this morning. But we have a Delta which is associated with a GOES launch vehicle. We had a valve problem, and that will—incidentally, as I understand it, we will be launching that tomorrow. We were pleased to find that that was a minor problem. So, we do launch for other agencies. We have COBE coming up in 1988, but the funding for it, of course, is 1987 funding.

Mr. PACKARD. Have you any estimate, or has there been any work done to evaluate how much payload we are losing to foreign launch procedures?

Mr. MYERS. We don't have any formal responsibility for that anymore, Mr. Packard. The policy of the administration has been that we will not launch commercial satellites.

Mr. PACKARD. So you are assuming that much of that will go to foreign operations?

Mr. MYERS. I know that some has gone to foreign expendable launch vehicles. I don't know how much. I think that Ariane was ready to jump into the breach and launch some of those satellites, but Ariane has had a problem with their upper stage and they are having their own problems. There has been some talk about Westar going on Long March, which is the Chinese launch vehicle.

I don't know where they stand in their final deliberations and negotiations there.

So, unfortunately, or however you want to look at it, we really are not in the business of tracking that in detail anymore.

Mr. PACKARD. Are you planning to submit for any funds or request any supplemental appropriations? Are you planning in advance ot seek a supplemental for either ELV operations or other efforts?

Mr. MYERS. We haven't really sorted that out yet, Congressman. We have got to look at this overall issue of our threats and the problems that we deal with in a very tight deficit year, and we were going to look at whether there are offsets within our own budget that we could squeeze by in these things or we will talk to our friends at OMB and we will have to determine how we're going to do it. We are determined that it is extremely important that we get a few expendable launch vehicles into the program, and we don't know how to do it yet.

Mr. PACKARD. You have heard the chairman of the committee comment on the increased budget commitments that we are interested in as a committee. That is not tracking totally with the President's budget proposal. What is your reaction to that request for increase from the committee?

Mr. MYERS. Well, I think we have noted it with interest, I think. We are part of the administration; we have to support the budget that we have. We think the budget is a good budget that we have from the administration, but we know that we have some really major problems in the space program. We can only recognize that these kinds of additions, if they occur, would be—we recognize that everything that has been proposed are good things to do. The issue is that we are committed to the budget that we have.

Mr. PACKARD. One last question, Mr. Chairman.

When are you anticipating the delivery for the replacement orbiter?

Mr. MYERS. It is the spring of 1991. I don't have an exact date because they are still in the process of negotiating that contract with Rockwell. It will be, I am quite sure, be the spring of 1991.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Slaughter? Mr. McMillen?

Mr. MCMILLEN. Thank you, Mr. Chairman. As a new member, maybe you can give me some background on the reimbursable activity in your budget. In fiscal 1988, there is $961 million. What percentage of that number is just a pass through and what percentage of that would be a third party pass through?

Mr. NEWMAN. The great bulk of it is third party pass through. There are things basically that we do at the request of other people, which if they did not request it, we wouldn't do. I say that in that year because there is not shuttle operations money in the 1988 reimbursement plan. In the years where there is shuttle operations money, they do share the total cost of the operation and we rely on that money for the operation.

More than $600 of that $900 million is from the Department of Defense. The next biggest element is from the Department of Commerce, primarily for the weather satellites and the earth observing satellite operations.

Mr. McMILLEN. You are saying what percentage would be a pass through, about 80 percent?

Mr. NEWMAN. More than that; 98 percent. Essentially, all of it is a pass through in the sense of—maybe I'm not answering the question right. If you are saying only money that we turn around and contract to somebody else for, most of it is still in that category. There is some money for things that we do at our installations, but it is pass through—it is not money that we rely on for the most part because they are things that we would not do if not for the request by the other agencies.

Mr. McMILLEN. What would be the figure of the dollars that you rely on in fiscal 1988?

Mr. NEWMAN. In research and program management, there is $13 million in that category. I'd say that is most of it right there, that we rely on.

Mr. McMILLEN. I guess my question is, and I am just trying to sort through this thing, to getting a better handle on how this particular budgeting works. On the budget summary, I'm not sure I follow where the reimbursables fit into that.

Mr. NEWMAN. The reimbursables are in addition to that. They are not included on the first page of the budget summary. That's money that we request for appropriation to us. Your $960 million is over and above the $9.5 billion.

Mr. McMILLEN. Does any of that net out to you specifically? What I am asking is any of that really nets out to you that has not been unallocated in this or not allocated in this budget?

Mr. NEWMAN. The $13 million that I mentioned——

Mr. McMILLEN. Besides the $13 million.

Mr. NEWMAN [continuing]. We did not receive that. We would have to budget for it. As I say, if there were shuttle operation reimbursements in that year, they would be in that category. I think on page 20, you see in fiscal year 1986, there was about $270 odd million that came into shuttle operations. The rest of the money basically is money that we would not require. I guess one exception to that would be some of the weather satellite work at the Goddard Space Flight Center. If the National Aeronautics——

Mr. MYERS. Oceanographic.

Mr. NEWMAN. National Oceanographic and Atmospheric Administration were not funding that, we would probably do some of the related work.

Mr. McMILLEN. That answers my question, Mr. Chairman. I was just concerned because you had asked for a detailed accounting of this. I don't know if this satisfies your request. As someone new to this, I'm not sure it does.

Mr. NELSON. Would the gentleman yield?

Mr. McMILLEN. Yes, sir.

Mr. NELSON. Let me follow up on the point you have raised about the $900 million. You are saying in fiscal year 1988, that you are planning for $900 million?

Mr. NEWMAN. $960 million.

Mr. NELSON. In reimbursables?

Mr. NEWMAN. That's an estimate, of course.

Mr. NELSON. Where is that coming from?

Mr. NEWMAN. Well, the bulk of it comes from the Department of Defense, $620——

Mr. NELSON. In fiscal year 1988?

Mr. NEWMAN. Yes, sir.

Mr. NELSON. We had that special appropriation for you, $531 million in fiscal year—last year, in fiscal year 1987.

Mr. NEWMAN. Some of that is for shuttle operations. We do a great many things with the Department of Defense. For example, the Navy uses facilities at the—it used to be the Mississippi Test Site, NSTL. We do aeronautics work in cooperation with them.

Mr. NELSON. All right. I see what you are saying. Now, are you saying that in the budget that you are presenting of roughly $9.5 billion, that over and above that will be another $900 million for you to spend in fiscal year 1988?

Mr. NEWMAN. To do things that have been justified by other agencies.

Mr. NELSON. To do specifically those things? Not shuttle operations?

Mr. NEWMAN. None of that is for shuttle operations.

Mr. NELSON. All right.

Mr. MCMILLEN. Mr. Chairman?

Mr. NELSON. Yes; absolutely.

Mr. MCMILLEN. I guess my question is, would it be possible to again ask for a detailed accounting of this, where its sources are?

Mr. NEWMAN. Yes, sir. We have provided in the larger budget book, more of a breakdown of that. We have provided the staff with a further breakdown.

Mr. MCMILLEN. Very well.

Mr. NEWMAN. We would be glad to do that. We have it by agency and by purpose. Let me add this, that we are estimating at this point what those agencies will get approved in their budget and once they get it approved, we are also estimating that they will make a decision to have us do it.

Mr. MCMILLEN. The reason that I am asking this and the point of my question is as the shuttle launches begin again, this reimbursement number is going to get bigger and bigger and bigger. I think it is very important that at least the Committee has an understanding of where these dollars are going. That was really the purpose of my question.

Thank you.

Mr. NELSON. All right. Now, Mr. Newman, we have information from GAO that says that in fact some of these reimbursables are being used, are expected to be used for shuttle operations. We don't have a formal report from GAO yet but we have it on the way. Once we get it, we are going to need to sit down and have a prayer meeting with you to get some clarification there.

You are saying unequivocally that these reimbursables are not going to be used for any shuttle operations?

Mr. NEWMAN. I would be glad to pray with you. [Laughter.]

In fiscal year 1986, we did, as I say, have about $270 million. In fiscal year 1987, we actually have a negative flow, we have to pay back some of the people who were dropped off the manifest.

Mr. NELSON. Sure.

Mr. NEWMAN. In fiscal year 1988, we do not have any planned reimbursement for shuttle operations. In fiscal year 1989, we do, because by then we will be back and you will have in effect blown off the DOD backlog and we will again be receiving reimbursements from DOD and from some of the commercial customers who are still on the manifest because they were shuttle unique. I would be glad to lay that out.

Mr. NELSON. OK. Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

I don't like to do this but I am going to start off, since I wasn't here a little earlier, got caught in traffic, Mr. Chairman, first of all, ask unanimous consent that the statement I had for opening remarks be inserted in the record.

Mr. NELSON. It is already in the record.

Mr. WALKER. I thank you. I am going to use a part of that as a statement before I ask some questions to kind of frame the questions.

My concern here is over the space station. For the past two years, this Committee has consistently told you that NASA needs to define a mission for the station and to address the questions of construction and operational costs. In all honesty, I have to tell you, I have yet to see sufficient justification to go forward with a $8 billion space station.

Now we understand that NASA and OMB have agreed that we are no longer talking about an $8 billion station. We hear that the number has grown to $14.5 billion or $15.1 billion, if you compare apples to apples, and that number grows to more than $20 billion if you count in real year dollars, which is the only way to count, since we are going to have to pay for it in real year dollars, not 1984 dollars.

If we are talking about that kind of money, I have to tell you that the space station is in real trouble. We have yet to bend the first piece of metal for the station and the costs have more than doubled. There comes a time when we have to start asking, what are we going to get for this investment and does it make sense? Is there something else that makes more sense? Can we afford to move forward with a project that is already estimated to cost more than $4 billion a year for the three or four peak years, those peak construction years, within a NASA budget of only $9.5 billion?

Unless we can be assured of a major long term commitment from OMB to adequately fund the nation's civilian space program, we have to question whether we can afford to move forward into a program of that size. We would literally be talking about spending half the budget to do nothing but build a space station.

When I come down from that, let me ask you a few questions about what's included in the funding estimates that I have just given you.

For example, does the figure forwarded to OMB by the Administrator for Space Station include the $750 million in Phase A and B funding?

Mr. MYERS. No; it does not.

Mr. WALKER. It does not. The money that we are now talking about, the $14 to $15 billion, doesn't include what we have already spent?

Mr. MYERS. May I speak to that subject, sir?

Mr. WALKER. Sure.

Mr. MYERS. When the Space Station was estimated at $8 billion, it was estimated after one tenth of one percent of the costs associated with the program had been completed. In other words, it is what we used to call in industry, a WAG. We have since that time gone through a Phase A and a Phase B program. The whole concept of a Phase A and a Phase B program is to define the requirements and the costs. We have continuously suggested and I am sure testified that even though it was an $8 billion program, we would have better estimates at the end of our Phase B program. That's where we stand.

We now have identified the full requirements for the Space Station. We have identified the activities that we will carry out with the Space Station. We have the cost estimates essentially complete.

We now are in the process of dealing with OMB on the issue that you raise. It is a very good one, sir. The question of the continuing support of the Administration for a program of this nature.

Mr. WALKER. Let's follow on though and find out whether or not we are really talking about a full program here. That's one of my questions.

Does the estimated cost as submitted, as now being worked on, include the cost of the crew escape life boat?

Mr. MYERS. I have to be a little careful here. We are in the process of defining some options to the Administration that includes such things as potential suppression of funding, which means that the operational dates move out a little bit. We are also looking at options that involve some phasing of the program. What those do is they suppress funding. They change when you get certain of the requirements met. In other words, they change dates that you get certain requirements completed, like, for example, when do we get a full-up capability. Those things are all being worked on right now.

Mr. WALKER. I am talking about the $14.5 billion that we now understand that OMB and NASA have agreed to as the cost of the station.

Mr. MYERS. We are not in a position to say what the cost of the Space Station is at this time. The $14.5 billion—I think Jim Fletcher said that is in the ballpark when he was at the Full Committee hearing.

Mr. WALKER. I have reason to believe based upon some information I've seen that it is not only in the ballpark, but that's the figure that OMB is now working with.

Mr. MYERS. That's one of the figures they are working with.

Mr. WALKER. Well, fine. Let's take that as the working figure, because that seems to be a working figure. Does that figure include the cost of the life boat?

Mr. MYERS. Depending on the configuration, it might and it might not. The specific—I just can't——

Mr. WALKER. The life boat is estimated to cost somewhere between $1 and $2 billion. Is that $1 to $2 billion included in that $14.5 billion?

Mr. MYERS. The life boat is something that we have only recently been studying. It has not been carried out in the Phase B program.

We are not ready to describe the cost of a rescue vehicle at this time.

Mr. WALKER. So that is not included in the $14.5 billion?

Mr. MYERS. It is not included in what we call the baseline program and I'm not at liberty to discuss the cost of the baseline program.

Mr. WALKER. The original $8 billion station included an outfitted laboratory. Is that included?

Mr. MYERS. Certainly the baseline program does have an outfitted laboratory.

Mr. WALKER. In other words, in the station, we are talking about being able to go with the scientific and technological costs from the very outset?

Mr. MYERS. Yes. Certainly the Station—let me describe what we are trying to do with the Station. To begin with, the Space Station has always been an element of the long range goals that have ever been described for NASA. The program studies that were made—I guess I will have to go back to Von Braun's activities in the early days of Apollo where he described the program that involved a reduction in the cost of launch vehicles and then a Space Station, so that we could have a combined program for microgravity activity and for science and space. That element of the Space Station also was always an element of all the programs including the latest one of Dr. Paine's, where the Space Station is a basic element of going out beyond the low orbit activities of earth to the moon or to Mars.

I think it is a fundamental part of the vision of NASA and a fundamental part of the interests of the public of the United States.

Now, my point is that the Space Station does include science and it does include advanced technology. It does include commercial activities. It does include life science, life science leading to long duration man flights in space.

Mr. WALKER. The $14.5 billion includes all of the equipment needed in the laboratory to do the experimentation, the experiments planned in the laboratory?

Mr. MYERS. No, excuse me. I didn't understand your earlier question, Mr. Walker. The Space Station is a laboratory like a research laboratory. It involves the supply all of the power, the environment, the data system, the attachments, the steering mechanisms, all the elements that set up a laboratory in space. It does not include the cost of the experiments themselves.

Mr. WALKER. So, over and above the $14.5 billion, we would still have the add-on costs of fully equipping the laboratory to do the experiments?

Mr. MYERS. That's correct. I might add that and one of the points that I had to pick up after I came to NASA was that the polar platforms that are included in the costs of the program are again stable platforms, environmentally correct, to carry instruments but do not include the cost of the instruments themselves. It's like the Space Station in that sense. It is a laboratory that can be serviced and continued and instruments can be changed but it is in polar orbit.

Mr. WALKER. What we are getting here is essentially the operational shell and then we are going to have to plug the components

in and then the component costs are not included in the $14.5 billion?

Mr. MYERS. It's an equipped lab. I wouldn't call it a shell. It is certainly a very highly sophisticated equipped laboratory with the best data systems, the best transmission systems that you can invent.

Mr. WALKER. But they are generalized systems that you would put in a laboratory.

Mr. MYERS. Yes; that is correct.

Mr. WALKER. Then the scientists would come in and plug in their experimentation——

Mr. MYERS. That was the whole concept. We have had very strong activities with the science community to be able to set up that laboratory so it would do the right job for them, for the kind of instruments and scientific experiments that would like to carry aboard.

Mr. WALKER. You mentioned a few moments ago the business of having this as a way station for a number of other things that we want to do in the future. Can the space station as configured for the $14.5 billion be used as a base station for the moon and for Mars?

Mr. MYERS. The Space Station is designed so that it can be used that way and we have looked at that. We have looked at the elements that would be involved in storing fuel and in bringing about the assembly of a transfer device to transfer to the moon. There would have to be structure added to the Space Station to be able to do that.

Mr. WALKER. How much would it cost to reconfigure it that way?

Mr. MYERS. We have not estimated the cost of those additions that would be involved to do a program of that nature.

Mr. WALKER. It would be a fairly substantial upgrade, wouldn't it?

Mr. MYERS. From what I saw of it, it is not a very substantial upgrade. The system is set up to be able to service. It is set up such that structure could be added and the design that I've seen, which is a preliminary design, shows how that structure would come out of the plane of the Space Station with a structure that would retain the tankage and the structure involved for a transfer of Station to go to the moon or Mars.

Mr. WALKER. The station that we are buying for the original $14.5 to $15 billion, does not include the capability to use it as a way station to either the moon or Mars; is that right?

Mr. MYERS. It has all the basic elements. I think the whole idea of the Space Station is to give us the flexibility to go in the direction that we all agree we should go in the future. I want to be sure that the Space Station has the flexibility to grow if we need, for example, additional activities with respect to commercial material processing, I want to be able to add that kind of capability to the Space Station. I want to be able to add more attached payloads, if that turns out to be the direction the system goes. It is like a modern research laboratory. It has to have flexibility to grow as experiments change with time.

Mr. WALKER. Obviously, if you are designing it with some of those upgrades in mind, you have some idea as to what some of

those upgrades might cost you. What is your best guess as to what that particular one is going to cost?

Mr. MYERS. I don't think we are in the position to really estimate the cost of those elements that are involved, for example, to go back to the moon. That would be a new element of additions to the space station.

Mr. WALKER. We are going to talk in general ranges about what the price of the station may be. It may be $13, $14, $15, $16 billion, I mean, are we talking here about $1 billion, $2 billion, $3 billion?

Mr. MYERS. I really can't give you an estimate on that. I don't know. I think the problem we get into in these things is we get pressed so hard for a cost estimate when we have done almost no studies on a program and then those numbers get locked in and that is not correct to have that occur because we have just not studied it sufficiently to give you an estimate of that cost.

Mr. WALKER. What is the expected annual operating cost of the station?

Mr. MYERS. We haven't really reviewed that either. We have a very good team of people that have been operating for about six months reviewing the operating costs of the program. We have a rough estimate of $1 billion a year as a base for operations. We have not really done the final reviews of those inputs. I will say it is our top team in NASA that has been doing that estimating job.

Mr. WALKER. It is at least $1 billion?

Mr. MYERS. It is on the order of $1 billion a year.

Mr. WALKER. At least $1 billion?

Mr. MYERS. I would say at least.

Mr. WALKER. None of that figure of $14.5 to $15 billion, and I think we talked about that earlier, I think I heard the Chairman mention it as I was coming in the room, includes the cost of delivery of the station to orbit; is that right?

Mr. MYERS. It does not include the cost of the launches. Let me add a point on operations, Mr. Walker. We put a lot of effort into the Space Station from the standpoint of reducing the operating costs, because the Space Station is going to be around for 20 or 30 years up there and it probably is going to be involved in some things we haven't even imagined yet as time goes by. We wanted to do what we could to reduce the cost of operations.

For example, let me give you an example. We have gone to a hydrogen-oxygen reaction control system for stabilizing the Space Station. The reason we did that is twofold. Number one is we were able therefore to get rid of a lot of contamination that would affect science experiments that are attached to the Space Station, but more than that, we wanted to have a system where we could reduce the cost of transport of fuels for the RCS system to orbit. We have designed the system to reduce the amount of transport requirements to the Space Station. That's money that we are avoiding by designing it into the research and development program so that it reduces the operating costs.

Mr. WALKER. You are certainly to be congratulated for doing that. That is obviously something that this Committee would be supportive of.

I want to come back to the launches for just a minute. How many launches are we talking about to get the station that we are

going to spend $14 to $15 billion on into orbit? How many launches is that?

Mr. MYERS. The number associated with getting the first permanent manned capability is of the order of eight—I'll have to get those numbers for you. It's of the order of eight launches for permanent manned capability, but there are some logistics flights then that start happening, to where you finally get your full capability with something of the order of 25 flights over a series of years.

Mr. WALKER. Now, not all those 25, though, would be complete shuttle loads for——

Mr. MYERS. They would be complete shuttle loads, including some of the science experiments being brought up.

Mr. WALKER. OK. All 25 would be?

Mr. MYERS. No. Some of those would be fully loaded with equipment—I mean with Space Station hardware itself being brought up for assembly. That's, even the early flights, we have some science for attached payloads that we bring up in, I think, the third launch.

Mr. WALKER. OK. But the eight flights are full loads, for the most part?

Mr. MYERS. The eight flights are essentially full—no? Even those have some science experiments. Those early eight. But they are all dedicated missions to the station. That's a better way to say it.

Mr. WALKER. OK, they are dedicated missions. But at the cost of those eight alone may be somewhere in the vicinity of $1.5 billion, and——

Mr. MYERS. Those are your additive costs, that's right.

Mr. WALKER. With the additive costs, that's right. And then if you go to the 25 missions, if those are dedicated—if those are dedicated missions as well, we are talking something in the range of, you know——

Mr. MYERS. Could I pull back on a point I've made? I made a misstatement. When I said those are additive costs, those are the numbers you are using are higher than the what we call additive costs to the program. We have got a base of operation down at the Cape that are involved down there, and we show a certain incremental cost for each launch, and if you look at that incremental cost, it's of the order of $80 million a launch.

Mr. WALKER. OK. So $80 million——

Mr. MYERS. So the numbers are really applied to dedicated missions.

Mr. WALKER. That's probably the fairer figure to use. So at that point we are talking somewhere around $650 million for it——

Mr. MYERS. Yes.

Mr. WALKER. But with the 20, say 20 flights, we would be talking something in the vicinity of $1.6 billion.

Mr. MYERS. Yes.

Mr. NEWMAN. Over several years?

Mr. WALKER. Over several years?

Mr. MYERS. That's right.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Tomorrow we have Dr. Stofan in front of the committee to talk about his specific request. We would like answers to these questions that have been——

Mr. MYERS. We will have it.

Mr. NELSON [continuing]. Propounded to you by Mr. Walker.

Mr. MYERS. We will do that.

Mr. NELSON. And we'd like some specific answers. We are moving on a fast track to mark up, by the end of March, and when we mark up, we are going to put a figure in this budget. So we are going to need to have some answers, Mr. Myers, before we put that figure in the budget, or else we may not put a figure in the budget.

Mr. MYERS. Mr. Chairman, we are well aware of that problem that we are having, and we are unfortunately in the position where some of the specifics we haven't thrashed them out. We don't have the answers on some of them. We will certainly give you all that we possibly can give you tomorrow, and we will follow up as we get additional information.

Mr. NELSON. Can you give us an estimate of when the RFP is going to go out?

Mr. MYERS. No, I cannot.

Mr. NELSON. Will Dr. Stofan tomorrow?

Mr. MYERS. No. He and I have been working hand in glove on this whole issue, and we do not have an answer as to when the RFP will be sent out.

Mr. NELSON. Can you give us a ball park? Are we talking about one week? One month? Or six months?

Mr. MYERS. No, I really can't.

Mr. NELSON. OK. Ask Dr. Stofan to please answer that.

Mr. MYERS. I'll ask him to answer it. I will assure you that he cannot give you any better answer than I can.

Mr. NELSON. Not a ball park, either?

Mr. MYERS. No, I think the problem is that we are dealing with a whole bunch of issues that involve funding threats to NASA within the Administration, and we are looking at options that may or may not be able to save money, or slide the Station, and those elements are being looked at very carefully and very aggressively by the Administration, but I really can't give you an answer as to when—and we have to get that settled before we can put out the RFP.

Mr. NELSON. Well, I realize the difficulty that you are in, because you are at this point prohibited from giving any detailed information, because you haven't worked it through all your clearances within the Administration. I understand your predicament.

Now let me tell you our predicament. On or about the 25th of March, we are going to mark up. Do you expect to have an RFP out by then?

Mr. MYERS. Boy, I sure hope we do. We're working every angle we can to make that happen, sir.

Mr. NELSON. OK. The political realities are that if we don't know what is going on with specificity by the time we mark up, you realize the political constraints that we are operating under when we make choices of funding in what is going to be the NASA authorization bill.

Mr. MYERS. Yes, I understand that. I think the point that I could make in passing, and probably not too important to the real issues

that you folks are dealing with here, is that all of the elements that we have looked at certainly have not changed the 1988 dollar requirements for the program.

Mr. NELSON. But it certainly does change the deliberation of this committee.

Mr. MYERS. I understand that.

Mr. NELSON. Because we are not going to go ahead and authorize $767 million unless we know that you have got a firm fix.

Mr. MYERS. We understand that, sir.

Mr. NELSON. OK. As long as we are understanding that.

Mr. Walker.

Mr. WALKER. Well, it has massive implications for 1989 and 1990.

Mr. MYERS. Oh, absolutely.

Mr. WALKER. And so, I mean, you know, we want to know what we are spending in fact is getting us down the road.

Mr. Chairman, if you will indulge me a little bit——

Mr. NELSON. Certainly. Certainly.

Mr. WALKER. But one final—Mr. Newman, isn't it true that you had figures higher than even some of those that I cited that you argued for with regard to the space station within NASA?

Mr. NEWMAN. It's true that we did an independent review, people who work in my office said in a number of areas their assessment of complexity was higher for the base than was that of the program office. We did review that, and we are at peace with the figures.

Mr. WALKER. But there are some arguments that exist obviously within your office that some of these costs are lower than some valid estimates might otherwise say?

Mr. NEWMAN. Many of the areas, in estimating the things of the complexity of the Station, do involve judgments which different people would judge differently.

Mr. WALKER. Can you give us some idea as to how much higher the figures were that were in your office than the figures that we are now working with?

Mr. MYERS. Could I answer that one? Mr. Walker, the reason I wanted to answer is that I have spent personally a tremendous amount of time in this process, and I have had a lot of experience in estimating costs. We have worked on a cost estimating process that involves everything from grass roots estimates from subcontractors as to cost elements where you can really define what is involved, to a lot of pretty ethereal complexity factors for things you can't understand. You deal with issues like the interaction between various centers working together, several different contractors, international inputs. All these things have a tendency to make things a little tough to estimate.

The program made an estimate. Tom Newman had a group of independent guys looking at the basic data, but making their own estimates. The values came out different. Jim Fletcher and I went over the value data that Tommy's people had. I went over the stuff the program had. Jim Fletcher has done the same, and we finally ended up with a number that we believe is a good number for the baseline to work in dealing with the OMB. That number was certainly higher than we had expected, and it ends up with a number

which still gives a margin of reserve, even with the number that Tom Newman came up with.

Mr. WALKER. But to follow up on the point that the Chairman makes, we are making some very fundamental decisions here ourselves on the same order that the decision you made within the agency. Not all us come at it with a great deal of technical expertise. We've got—we've got to react based upon the technical expertise that you give us. If there are a range of estimates within the agency, it seems to me we have some need to know what those range of estimates are, because it—because in order to honestly evaluate the whole system, you are the only people who know this system at the present time. You are the people who have studied it. It seems to me that we have some obligation to know, based upon what you're doing, what the range of estimates might be, and you know, it would be helpful for me to know whether Mr. Newman's figures were 10 percent higher, 20 percent higher than the baseline. What kind of differentials are we talking about here?

Mr. MYERS. That's a good question, Mr. Walker, and I think once we have sorted out, gotten through our maze within the Administration, I would very much like to go over those differences with you.

Mr. WALKER. OK.

Thank you, Mr. Chairman.

Mr. NELSON. I tell you, you might pass on to Dr. Stofan before his testimony tomorrow, that one of the things we also want him to describe for the committee is since the Soviets have two space stations up right now, what does he anticipate to be their capability along about 1994, as compared to the capability of the United States in what you-all are planning for in your station. And let's trace that for the committee members, particularly the new committee members.

Mr. MYERS. We'll do the best we can. That's a little difficult to estimate.

Mr. NELSON. I understand.

Mr. MYERS. But we can certainly start with where they are and what sort of potential we could visualize they might have at that time.

Mr. NELSON. Mr. MacKay?

Mr. MACKAY. Thank you, Mr. Chairman.

I—in an article published in the February 13th issue of Science Magazine, the NASA chief scientist states that a renewed emphasis on moderate-scale, quick-response missions will be of special importance of scientific progress, and will compensate in part for the postponement of most major space missions.

Do you agree with that comment?

Mr. MYERS. We are certainly, during this hiatus of flight, there has been a tremendous review by the science community as what else do we do now. What can we do to really get some science going while we are waiting to get back to these major activities. And we have brought in some smaller payloads. We have a lot more emphasis going on in our Wallops Island operation, where we have very small launch vehicles, where we can develop new instruments, and where we can have the science community involved, even though not with the spectacular science that is yet to come with

Hubble Space Telescope and the other major observatories that we have. The littler ones still are very important, and we agree that there should be more activity in that area.

Mr. MACKAY. Does your budget reflect this renewed emphasis?

Mr. MYERS. Yes, we brought in—what's the name of the program that we brought in for—yeah, the Vitality—it's called the Vitality program. It was something where, after the accident, there was such a tremendous letdown in the science community that we did bring in a program called the Vitality Program, to be able to stimulate the active participation of the university of scientists and all the cadre of scientists that have been involved in our programs, in a way that they could be still reaching forward in their own science and technologies, but with much smaller elements, while we are waiting to get back into flight for the shuttle.

Mr. NEWMAN. I'd like to mention two other things. We did, as you know, specifically make arrangements to launch the Cosmic Background Explorer, the COBE mission, and also we have augmented the airborne research program, which is something we can do during the hiatus of shuttle flights.

Mr. MACKAY. Do you have any plans for a series of modular spacecraft that could support a variety of missions that would be less expensive because of economies of scale?

Mr. MYERS. Yes. We have a program called Get-Away Special, which are literally cans that can be put in the shuttle payload bay, and we also have a program called Spartan, which has been pursued from—at our Goddard Space Flight Center, a tremendous program of being able to quickly reconfigure a platform with different science objectives on different platforms, to be launched from the shuttle program. Those are all called secondary——

Mr. MACKAY. But do you have anything that is independent of the shuttle that would assure the science community that there is going to be science going on independent of what happens to the shuttle?

Mr. MYERS. Well, of course, the COBE is one of those, the background investigation that will be a small payload launched by Delta. We have activities launched by small launch vehicles from Wallops Island. We have activities in our airborne program where people with very long duration high altitude airplanes can get up almost above the atmosphere for investigations. And all of those programs have been emphasized across this period of time.

Mr. MACKAY. And we'll be able to see that specifically in your budget? We'll be able to see increases that show that emphasis?

Mr. NEWMAN. You'll see the increase in the airborne, you will see the rearrangement of funding to provide for the COBE mission.

Mr. MYERS. You'll see the Vitality Program.

Mr. NEWMAN.You'll see the flexibility of the Vitality Program.

Mr. MACKAY. Mr. Chairman, if I might, I'd like to pursue just one other question that arises out of the earlier discussions with Mr. Walker about the space station.

Mr. NAGLE [presiding]. I'm considering granting your request. [Laughter.]

Mr. MACKAY. You mentioned that there had been sufficient—you mentioned that there had been sufficient studies now so that

the full requirements of the space station are known. Do those requirements include military requirements?

Mr. MYERS. Now there have never been any military requirements for the Space Station. There has also been an understanding that there may be some day, but I think when I say we have defined a Space Station, we have defined it as a civil Space Station. We have defined it as a very flexible device which can accept differences as they develop, such as I visualize personally that the material processing business is going to get bigger with time, and we want to be able to give the flexibility to have that occur.

On the other hand, I think, as we have always done, it should be possible for experiments that meet the peaceful use of the civil Space Station to be allowed in the Space Station, because I think it's important to the military security of the United States.

Mr. MACKAY. Are the provisions for future military requirements such that we are not, as a practical matter, going to be able to operate the space station as an international project?

Mr. MYERS. No, everything we are doing is to make the Space Station so that it can operate as an international program, and we have been very vocal in that. I think the Space Station is a civil Space Station, it is an international Space Station, and we are continuing the negotiations with the Europeans on making that happen.

Mr. MACKAY. Is it not, though—is it not then appropriate for us to say how come, with all of this cost overrun, we don't have others stepping up to say we are going to be part of this?

Mr. MYERS. Well, there aren't any requirements right now by the military, and I personally——

Mr. MACKAY. Well, are there reservations such that our international partners are not willing to proceed?

Mr. MYERS. No, we are proceeding, as a matter of fact today in Europe, on the negotiation of the agreements for an international use of the Space Station. We have always told the Europeans that there may be uses of the Space Station by the military, and from the first meeting that Jim Beggs had in Europe, there were discussions of that nature. And so there's no surprises in this. There's been a lot of noise recently, but no surprises.

Mr. MACKAY. When would we expect to see the international agreement reflected in the budget? I mean at some point we are going to have to make a commitment, and before I personally am willing to make that commitment, I want to know is there going to be international money in this or not?

Mr. MYERS. Well, let me at least understand the question. The way the Space Station is set up, we supply the American portion of the Space Station and the infrastructure on the ground for that activity. The Europeans pay for their own hardware that is attached to the Space Station and, in fact, have some infrastructure of their own on the ground.

Mr. MACKAY. And so we are not really talking about an international program, we are talking about a national program where they could hook their national program to it?

Mr. MYERS. We are talking about an international program in the sense that there are American laboratories, and European laboratories, and a Japanese laboratory, all associated with the Space

Station. The agreements that we are working on would allow us to utilize portions of their Space Station as an offset against the ground infrastructure that we have.

Mr. NEWMAN. If I could, I think it's a little clearer that there are laboratories provided by the Europeans and the Japanese and the Americans. The usage of those modules by agreement is intended to be proportional to the investment of each country in the Space Station as a whole, so that we would be using the equipment provided by the other countries.

Mr. MACKAY. But the 14 billion, 14.5 billion, that doesn't reflect any commitment on the part of anybody other than us?

Mr. NEWMAN. That is for the Americans.

Mr. MYERS. For the American portion, the United States portion of the Space Station.

Mr. MACKAY. So is anybody else going to put anything up there but us? Is there going to be any portion unless we put our 14 billion up there?

Mr. MYERS. If we don't put our Space Station up, there is no place for the European systems to attach to it.

Mr. MACKAY. All right. So I'm not trying to play a game. I'm trying to ask, has any thought been given to an international space station, where we say it's going to cost 14 billion, and we'd like to see the European share of that and the Japanese share of that on the——

Mr. MYERS. No, the original agreements that were developed with the Europeans was for the United States to develop a Space Station, for the Europeans to develop a laboratory that would be attached to that Space Station, and the European laboratory would be paid for by the Europeans, and the Japanese would do a laboratory. Those estimated costs, by the way, are above $3 billion for the European and the Japanese elements. Three plus. And so there is—if you want to look at it that way, the total international program would be three to four billion dollars more than the United States' portion.

Mr. MACKAY. I've just had someone pass me an anonymous note that said the Vitality Program originally had 18 million put into it, 16 million was moved out, so it only got 2 million of actual Vitality. Would you care to comment on that? That's not too vital.

Mr. NEWMAN. We have a lot more vitality than that.

Actually, is an augmentation to the basic scientific programs that were going on. The amounts reflected in this budget are $20 million in fiscal 1987, and $25 million in fiscal 1988. Of that Vitality augmentation. Those are in the figures that I presented to you.

Mr. MACKAY. All right. Apparently you are not doing too well in getting that message out to the scientific community.

Mr. NEWMAN. We will be glad to talk to the science community about that.

Mr. MACKAY. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON [presiding]. Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I have some concerns that I find in the budget under Space, Science & Applications on our space satellites, et cetera, and I see reductions, and if you are not able to provide the information I want

today, I'd appreciate you doing so in writing as soon as possible. Especially we find a $16 million reduction in the Galileo; I find 33 million in Magellan; and I think I can understand those two a little bit. But I'd like to have your reasoning why. And then also in the Gamma Ray observatory, and I think I understand that one, but I do not believe I understand the $7 million reduction in the Mars Observer, and 19 in UARS, 10 in Scatterometer. I understand the ACTS, you don't have to comment on that. I think we all know that. And then TOPEX, I find a plus, and I can understand that, the plus there. But the reductions up above, I'd like for you to give me an explanation, the reasoning behind those. With some of them, we're looking to a 1990 or 1991, you know, launch and yet it doesn't appear to me you're building to that. You're reducing it.

Mr. NEWMAN. Well, all of the hardware projects you have cited, the year-to-year phasing has to do with the development cycle. As you know, projects tend to build up, prostrate, and as they approach launch, to decrease.

Mr. VOLKMER. I agree with that.

Mr. NEWMAN. Now something like the Galileo is really on a cycle that was aimed at an earlier launch. Because of the shuttle problem the launch is delayed. So what we have done is go ahead in those projects that were well into development, and build basically against the earlier schedule, if the contractual status was such that it made sense to do that. So in something like the Gamma Ray observatory or the Galileo, you have the peak passed, the peak of the development requirement passed relatively early to a launch. So those are the normal phasing of development. It's true of the those.

The Mars Observer reflects the cutback from a planned readiness for the 1990 launch to a readiness for a 1992 launch. The Upper Atmosphere Research was really funded against an earlier launch, as again we are past the peak of funding requirement there. TOPEX is on the build-up, is on the front part of that curve.

Mr. VOLKMER. I can understand that.

Mr. NEWMAN. So in all cases, with the hardware projects, it's a phasing of the development activity consistent with the launch date that we now have.

Mr. VOLKMER. On UARS, you are reducing it because your launch date has been pushed back?

Mr. NEWMAN. Yes, we had had aimed that at an earlier launch, but the launch date had gotten pushed back, and we rephased the funding for that, and the requirement that you see there is consistent with the launch in, I believe, it's 1991, but I'll check that if you wish.

Mr. VOLKMER. I have 1991 on the—in between 1990 and 1991.

Okay. Now what is NASA's contribution going to be to the IGBP for 1986, 1987 and 1988?

Mr. NEWMAN. I think we'd have to answer that for the record.

Mr. VOLKMER. All right. I'd appreciate having that for the record.

[Information to be furnished follows:]

Through a number of NASA's Earth Science and Applications programs, research activities are presently underway to obtain a better scientific understanding of the entire Earch system on a global scale. This overall effort includes studies of global

change and is referred to as Earth System Science. The goals of Earth System Science research are related to the interests of IGBP whose recommendations have been very important to the workings of the Earth System Science Committee, the NASA Advisory Council, and NASA's Earth Systems Science research. At the present time, approximately $350 million per year of the Earth Science and Applications budget is used to fund research tasks that are related to the Earth System Science study effort. This figure includes funding presently being used to develop Earth Science and Applications flight projects (including UARS, Scatterometer, and TOPEX) which, when launched, will also provide data relevant to Earth System Science research.

Mr. VOLKMER. I have no further questions. Thank you, Mr. Chairman.

Mr. MACKAY. Mr. Chairman?

Mr. NELSON. Certainly.

Mr. MACKAY. If I might, can I ask Mr. Newman, since the Vitality Program is not a line item, would you give us for the record the details of that program?

Mr. NEWMAN. Yes, sir. I can give you a quick breakdown now, if you like, but we will provide that for the record.

Mr. MACKAY. Okay. That would be fine. Thank you, Mr. Chairman.

[Information to be furnished follows:]

March 10, 1987

Vitality Package

The purpose of the NASA Office of Space Science and Applications (OSSA) "Vitality Package" is to provide additional funds to the research community, particularly universities, to help researchers maintain active research programs during the present major hiatus of flight opportunities. To be effective in dealing with the current situation, such an infusion of funds must be directed to activities which can provide immediate research opportunities and yet which do not lead to a major, long-term obligation which OSSA may not be able to sustain once normal payload development and flight opportunities resume. The vitality program focusses on the two major areas which are most likely to produce short-term results: 1) continuation of basic research, analysis of data from previous flight missions, technology development in preparation for future flight missions, and continued operation and data retrieval from currently operating spacecraft; and 2) increased activity in the suborbital program as a means of providing near-term flight opportunities, allowing continuity in research for several science disciplines which can effectively use aircraft, balloons, and sounding rockets. A tentative allocation of funding across the various OSSA disciplines is shown in Enclosure 1.

The Research and Data Analysis part of this enhancement will be used to support a variety of activities. The planetary exploration program has been particularly hard-hit by the Challenger accident and the subsequent decision

to cancel the flight of the Centaur upper stage on the Shuttle. There is a substantial backlog of planetary spacecraft awaiting flight opportunities aboard the Space Shuttle or on Expendable Launch Vehicles if they can be obtained. There is a great concern in the planetary community concerning prospects for the future. The planetary portion of the vitality package will focus on Advanced Technology Development (ATD) for the Mariner II class of future spacecraft which are a major thrust of the long-term program strategy defined by the Solar System Exploration Committee. Near-term focus is on planning and mission development activities in support of the Comet Rendezvous Asteroid Flyby (CRAF) mission now under consideration as a major new-start.

Archival results from previous flight missions constitute a major resource which can be mined to obtain important new scientific results. For example, data from the previously flown astrophysics missions such as the High Energy Astrophysical Observatories (HEAO), the International Ultraviolet Explorer (IUE), and the Infrared Astronomical Satellite (IRAS) are available and there is much interest in combining data from the various missions. More than 200 letters of intent were received in response to the recently issued Space Science and Applications Notice for Astrophysical Multispectral Data Analysis. Spacelab-2 data analysis will also provide continued research opportunities for astrophysics as well as the space plasma physics community. Within the Earth science community, loss of Shuttle flights means an increased need for continued operation and expanded data analysis and Guest Investigator programs for satellites such as Nimbus, the Solar Mesospheric Explorer (SME), the Dynamics Explorer (DE), the International Cometary Explorer (ICE), and others. The research areas of materials science and life science which are critically dependent on Shuttle flights for access to space will use vitality package

funds for work on enabling technology development and supporting research in preparation for future flight activities. New approaches to carrying out flight experiments such as using augmented Discover capsules for doing experiments in space medicine and biology are also being investigated.

The suborbital Program enhancements will provide extra support for the ongoing aircraft, balloon, and rocket programs. By a variety of approaches (e.g., increasing the C-141 hours available, by converting smaller balloon payloads to larger facility class payloads able to accommodate guest investigators, and by increasing sounding rocket availability) new flight opportunities can be made quickly available to the research community allowing continued data gathering to help keep research groups active and provide ways of obtaining new results. Accelerated development of instrumentation for flight on facilities such as the DC-8 will permit geological studies using synthetic aperture radar (SAR), flight of ozone and atmospheric or oceanic species monitors, as well as biospheric experiments over the Amazon, malaria research, and coordinated interdisciplinary biogeochemical studies. Expanded availability and use of drop towers will allow new materials processing research. Sounding Rocket opportunities will provide for research in space plasma physics as well as a variety of astrophysics experiments in high energy and solar physics.

In summary, this Vitality Package represents a modest infusion of funds intended to help support a broad research community for a period of 3-4 years until Shuttle flights resume. Such activities should be particularly important for allowing graduate students to carry out research programs in the near term and for keeping university research groups viable. As Shuttle and

ELV launch opportunities are restored, the extent to which the basic research and analysis and suborbital programs need extra funds will decline and these research activities can then return to their normal funding level.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1988 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT DETAIL BY PROGRAM OFFICE
(IN MILLIONS OF REAL YEAR DOLLARS)

FY 1988 PRESIDENT'S BUDGET

| | | TENTATIVE ALLOCATIONS | | |
|---|---|---|---|---|
| | 1987 CURRENT YEAR | 1988 BUDGET YEAR | 1989 | 1990 |
| VITALITY PACKAGE: | | | | |
| P&A SRT | 3.3 | 3.3 | 3.3 | 3.3 |
| SOUNDING ROCKETS | 3.2 | 3.2 | 3.2 | 3.2 |
| LIFE SCIENCES R7A | 2.0 | 2.0 | 2.0 | 2.0 |
| PLANETARY ADVANCED PROGRAMS | 5.0 | 10.0 | 5.0 | 5.0 |
| SOLID EARTH R&A | 1.5 | 1.5 | 1.5 | 1.5 |
| ATMOSPHERIC DYNAMICS/RAD R&A | 1.0 | 1.0 | 1.0 | 1.0 |
| SPACE PHYSICS R&A | 3.0 | 3.0 | 3.0 | 3.0 |
| MICROGRAVITY R7A | 1.0 | 1.0 | 1.0 | 1.0 |
| TOTAL VITALITY PACKAGE | 20.0 | 25.0 | 20.0 | 20.0 |

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. I would like to, if I might, follow up on a conversation we had in front of the full committee that Mr. MacKay touched on. You indicated at that time no plans to militarily use the Space Lab; is that correct?

Mr. NEWMAN. Space Station. There are no requirements by the military.

Mr. NAGLE. I didn't ask about requirements. I thought I said plans.

Mr. NEWMAN. There are no plans to use it.

Mr. NAGLE. And you indicated that our European allies in Japan were in accord with the decisions that have been made in that regard?

Mr. NEWMAN. I indicated that the Europeans and the Japanese had always been told that there may be research, military research done on the Space Station that meet the peaceful use of space and the laws and regulations associated with that.

Mr. NAGLE. And they are in accord on that?

Mr. NEWMAN. We have ongoing negotiations with them. I can't say that they are in accord with it, but I would expect that they will be.

Mr. NAGLE. Can I read you some language that has been submitted to them under Article 9 of the proposed agreement, specifically paragraph 5 of page 7, which says, and I quote, "The United States may use the Space Station with NASA's allocation of user accommodations and utilization resources for any purpose, including national security purposes consistent with paragraph 6 of this article, Article 2, and agreement between the cooperating agencies."

I understand they are saying "what national security purposes are you talking about?" That is kind of my question, too.

Mr. MYERS. I would like to have Ken Pedersen, who is our Associate Deputy Administrator for External Affairs, respond to that question, Mr. Nagle. He has been involved in that activity much more than I have.

Mr. PEDERSEN. Mr. Congressman, that language is in there specifically to point out what I believe Mr. Myers has already said, that we have indicated that this is a United States facilities, those portions provided by the U.S. to the Space Station. From the beginning we have told the partners that the Department of Defense could be a future user of that consistent with peaceful purposes and international treaty obligations and so on.

They have no identified requirements, no plans that we are aware of. Nonetheless, that merely indicates that that option, which has always been an option, is available. That agreement to which you are referring was briefed to the international partners a week ago, and at the end of the briefing, all of the partners indicated that they were prepared to continue negotiations. So we are in a stage of negotiations right now, but they have all indicated that they are prepared to proceed with those negotiations.

Mr. NAGLE. If the Department of Defense has no present plans, why was it necessary to conduct three weeks of interagency negotiations with them over the uses that they be allocated on the Space Station?

Mr. PEDERSEN. I think that to depict the interagency meetings as being between NASA and DOD or between NASA and the State Department, on one hand, and DOD on the other is to slightly misrepresent them. There were several agencies, DOD being one, that felt we had proceeded along the negotiating path to a point where they felt that they wanted to have an opportunity to review where the negotiations stood and to what extent their particular interests, whatever they may be, were provided for.

The meetings took the amount of time that you are talking about for two reasons, principally. Number one, the people that were involved in them had a number of other job-related obligations, so the meetings took place a few hours each day or every other day. Secondly, the way they proceeded was to go through the draft agreement that was on the table at that time, literally article by article, line by line, to make sure that all of the agencies understood what was in that. That takes some time, but it was not a negotiation in the classical sense of that term.

Mr. MYERS. I think it is worth noting that the time that was allocated to do that work was met. The schedule was met.

Mr. NAGLE. Well, I think it is worth noting that my term "negotiations" is the term that Dr. Fletcher used when he testified in front of us. As a matter of fact, he said, and I believe I quote correctly, that the negotiations weren't completed until 11:00 the night before the day he came here. So you don't want to quibble with a term that Dr. Fletcher used about negotiations, do you?

Mr. PEDERSEN. Well, Dr. Fletcher's definition of negotiations may differ from mine. Negotiations imply to me a relationship between two parties in conflict or in potential conflict. This involved 11 agencies sitting around the table going through this document in detail and was not a bilateral negotiation in the sense that I would define that term.

Mr. NAGLE. Again, I guess I am still confused because I asked if the agreement with the Department of Defense had been reduced to writing, and Dr. Fletcher told me it was. I asked if the committee could have a copy of that memorandum agreement, and I was told that we would have it. My staff person, who is in the back of the room, called and we were told that it was on the way, and the committee staff has called and has been told it is on the way. When do we get it?

Mr. PEDERSEN. Congressman, the document that was executed and was completed at 11 you referred to was the intergovernmental agreement that was concluded by the interagency group and cabled to the potential partners abroad at 11 that evening to which Dr. Fletcher referred. There was no signed memorandum between DOD and NASA. The IGA, the Intergovernmental Agreement, which has been supplied to the committee and from which you have quoted, is the document.

Mr. NAGLE. I also asked if there was a position paper that NASA had before these negotiations took place, and I was told that there was. I asked if we could have NASA's position papers during these discussions or negotiations, whatever you want to characterize them, and I was told that we would receive them. I still don't have them. The committee still doesn't have them.

Mr. PEDERSEN. Congressman, the position paper, if would I refer to that, was the earlier agreement that was on the table with our international partners. That was the document that was used. My understanding is the earlier drafts of the IGA have been provided to the committee in the same way that those were provided, with the assistance of the State Department, whose agreement it is.

Again, the meetings we are talking about involved all of the agencies going through that draft IGA, which was the position paper of all the parties. It certainly was NASA's position paper because it was the document we were involved in negotiating.

Mr. NAGLE. Who was there on behalf of DOD at this last meeting, the one that went until 11 at night?

Mr. PEDERSEN. DOD had three or four people there. The two leading spokesmen or the people that spoke most frequently for DOD were Frank Gaffney and Phil Kundsberg.

Mr. NAGLE. I was also told by Dr. Fletcher when he was here that we had to meet to certain demands—or not demands, that's a poor term, we had to meet certain "needs" that DOD had. I asked what those needs were, and I have yet to hear exactly what DOD's position was in those negotiations.

Mr. PEDERSEN. Well, I would have to defer to DOD to express what their particular objectives were. Insofar as I was able to ascertain, their principal concern and interest was in understanding the basic principles on which the U.S. was going forward, such principles as the importance that the U.S., NASA being the operative agency, would have overall management of the station to assure safe and effective operation of the facility, and that the U.S. would have the right to select the users for its portions, provided portions of the Space Station.

I think a fair term to use would be, as far as I am concerned, was DOD's position in the meetings was one of understanding and seeking clarification as to how we would propose to interpret those various principles.

Mr. NAGLE. How do you interpret "including national security purposes"? How does NASA interpret that?

Mr. PEDERSEN. I would interpret that to say that if DOD as a user at some point in time identified a requirement or a use for the station, that they would be evaluated and accommodated as we would any other national user so long as those uses were consistent with national policy, our commitment to peaceful uses of space, and obviously our international obligations as well.

Mr. NAGLE. You mean there is an understanding between NASA and DOD that weapons cannot be deployed on the station?

Mr. PEDERSEN. I would not say that at all. There is no understanding between DOD and NASA regarding any specific requirement. They have identified no requirement, so I think to speculate on any particular requirement is just that, speculation.

Mr. NAGLE. If it is this simple, why did it take three weeks until 11 the night before the hearing? If you are going to consider any request they would make, it doesn't seem like it would take that long.

Mr. PEDERSEN. Well again, I would answer, Mr. Congressman, by saying that first, the way we proceeded was to go literally line by line down through that document, which, as you can see, is a fairly

lengthy one; and secondly, we did not meet every hour of every day. We averaged a meeting, perhaps, every other day. In some cases we met back to back, in some cases we didn't meet for a day or two.

So I don't want to leave the impression that the meetings were 12-hour-a-day meetings every day of the week. We were given one month's time to do it. The international partners were informed that we were taking a pause to review the document. They accepted that. We completed our work in the time allocated, and all of the milestones that were set were attained, so I think we felt that it was a successful review and not one whose length ought to indicate that there were great difficulties.

Mr. NAGLE. And you are telling the committee that the NASA agency went to these meetings with only a copy of the proposed contract in their hands and no interagency memos in terms of what your positions would be with regards to various languages or anticipated requests of DOD?

Mr. PEDERSEN. We went with that document which we and State Department had been negotiating on for close to two years now. I think we were intimately familiar with the document and what we believed the various clauses and articles meant, so we felt no need to have formal position papers in the sense I believe you are referring to because the purpose of the meetings were to essentially interpret and explain that document and sort of take them through the history of the negotiations so that they could review that document in a historical context.

Mr. NAGLE. Would you be willing for the record to provide me a detailed explanation of each change that was made in this document and the reasons for it?

Mr. PEDERSEN. Congressman, that would be a very, very extensive undertaking because many changes were made that were made of essentially a clarification, cosmetic, grammatical nature.

Mr. NAGLE. I will leave the grammatical and the clarification and the minor out. I want the substantive ones.

Mr. PEDERSEN. I would certainly be prepared to address that with State Department and get back to you. It is their document, after all. My hesitation reflects the fact that we are dealing with an agreement that essentially is another agency's principal document, but I would certainly endeavor to do that.

Mr. MYERS. I think another point we ought to consider is that it is a document that is in negotiation, and in that sense it is a relatively sensitive document, I think.

Mr. NAGLE. You are saying you won't do that?

Mr. MYERS. I'm not saying we won't do it. I think it is something we ought to consider—of course, I'm not in a position to do it. It is State Department's document and we will have to talk to them about it, but I think the point is we all know that when you are in a negotiation and in the sense of working with the Europeans on this thing, there is across-the-table negotiations involved. If we were to have a lot of detail public on that, I think it would influence our progress in those negotiations.

Mr. NAGLE. My colleagues are helping. What, if anything, is specifically prohibited aboard the space station? Is there anything in the agreement that prohibits the use of weapons?

Mr. PEDERSEN. The agreement specifically, as I read it, prohibits anything that would be inconsistent with our commitments to peaceful uses of space and our international treaty obligations, which involve the broad Outer Space Treaty as well as a number of treaties.

Mr. NAGLE. But some within the administration have argued that they think persuasively that the militarization of space ensures its peaceful uses; therefore, anything would—is there anything in the agreement that prohibits weapons from being distributed in outer space, anything in the understanding between yourself and DOD or between yourself and the European allies? Maybe I missed it in this document. Is there something in here that says we will not put weapons in space?

Mr. PEDERSEN. There is nothing in that document that uses those words; however, I would think any action such as you are describing—which is, I say again, speculative because there has been no indication from DOD that they have any interest in that regard—would have to be, of course, thoroughly reviewed in the Executive Branch as a major policy matter and would not be NASA's decision alone to make, in any case.

Mr. NAGLE. But it would also be a matter for the Congress, wouldn't it?

Mr. PEDERSEN. I would certainly assume so, yes.

Mr. NAGLE. So let me understand this. You are asking us, the committee, to spend $14 billion, roughly—and I recognize that is a ballpark figure—on a space station in which under the current understanding between DOD and NASA, and NASA and its European allies, weapons could be deployed or put on that station and there is nothing in any agreement that prohibits that.

Mr. PEDERSEN. I believe what we are asking you is to fund a civil Space Station operated by NASA, two principles which have never been in dispute, for which the DOD at this point has no identified requirements.

Mr. NAGLE. Except that apparently they are comfortable with the language that says "including national security purposes" and does not limit those in any way.

Mr. PEDERSEN. It does limit them, again, in terms of our obligations to peaceful purposes and, of course, our international treaty obligations. In that case, for example, the placing in space of weapons of mass destruction is specifically prohibited.

Mr. NAGLE. Say that again. I'm sorry.

Mr. PEDERSEN. It specifically prohibits undertakings that would be inconsistent with the peaceful uses of outer space and with our international treaty obligations. One such obligation, for example, is the obligation in the Outer Space Treaty, to which we are a signatory, that weapons of mass destruction will not be placed in outer space. That is one example of something that is specifically prohibited.

Mr. NAGLE. I have been told that our European allies and Japan have a major problem with the language that I have been quoting to you in paragraph 5 of Article 9 on page 7.

Mr. PEDERSEN. I can only indicate again that last week a meeting was held on a multilateral basis, representatives of Canada, Japan and Europe, in which the draft agreement was briefed. At the end

of that, a joint statement was issued in which they indicated they were prepared to continue and move ahead with the negotiations. I think Mr. Myers' statement that they understand that issue is an accurate one. It does not mean that they in all cases agree with it or even at this point necessarily accept it. That is what negotiations are in part all about.

Mr. NAGLE. Can you explain to me why Dr. Fletcher told us that this memorandum of agreement, this agreement between NASA and DOD, was reduced to writing, there was a memorandum of agreement, and why your agency called my staff and assured me that we would receive a copy of it?

Mr. PEDERSEN. Mr. Congressman, I can only respond to that by saying that the work was completed in the interagency process late the day before. I had not had an opportunity to see Dr. Fletcher that morning before he came to the hearing, so there may have been some miscommunication. What I am saying is that the only agreement that was executed in those meetings was the new draft of the intergovernmental agreement. There was no agreement signed between NASA and DOD, no memorandum of understanding, no MOU.

There is a record of the interagency review which is contained in a document prepared by the NSC, National Security Decision Directive, which is classified, and it is signed by the President, but there is no NASA/DOD MOU. So I am sorry, there is nothing to provide you in that area. I am sure what the staff was referring to, Mr. Nagle, was the IGA document which, as I said, was provided to the staff of the committee.

Mr. MYERS. That is what Dr. Fletcher had in mind. I talked to him after the meeting.

Mr. NAGLE. I appreciate the chairman's indulgence here. I want to pick back up on something you said. You indicated that "Our treaty obligations prohibit the use of deployment in space of weapons of mass destruction." DOD has taken the position that a laser weapon, for example, aboard the Space Lab is not a weapon of mass destruction, it is designed to destroy a specific target.

I assume that NASA concurs in that view?

Mr. PEDERSEN. I don't believe that is——

Mr. MYERS. I haven't heard that DOD does consider a laser for the Space Station. There has not been any input to us of that requirement on the part of the DOD.

Mr. NAGLE. You would concur, would you not, that one way to do this to make sure that we are only using it for peaceful purposes is when Congress appropriates the money, is to specify what uses the space station could be used for? You wouldn't have any problem with that, would you?

Mr. MYERS. I would sure rather have it consistent with the laws and treaties of the United States than something specific.

Mr. NAGLE. Well, I have got one question someone wants me to ask. In your view, would the testing of the SDI weapons be considered a peaceful use in outer space that could be conducted under the space station if the Department of Defense requested it?

Mr. MYERS. Well, I am not in any position to answer because I think it is a hypothetical issue. If you are talking about some kind of a sensor being tested or something of that sort, that is one thing.

A laser is another thing. I think it is issues that are settled by the laws and treaties of the land and the activities of the administration jointly with DOD, the State Department, the NSC and the whole works. I am not in any position to answer that question.

Mr. NAGLE. But at least in your view of the language we are sending to the Europeans, such a thing would not be prohibited?

Mr. MYERS. I didn't say anything of the sort. I said what is in that document is the basis under which we are negotiating the activities with Europe. The IGA is the basis of that activity, and we are going to negotiate with them concerning the use of the Space Station.

Mr. NAGLE. Well, you are using language in the agreement that says "including national security purposes." What are you saying, that you don't know what that means or that that could mean anything?

Mr. MYERS. It could mean anything that is consistent with the laws and treaties of this land.

Mr. NAGLE. Including the deployment of weapons.

Mr. MYERS. I didn't say that.

Mr. NAGLE. Well, OK. Could you provide us with the national security decision documents that you just mentioned?

Mr. PEDERSEN. Mr. Nagle, I talked to the staff of the National Security Council this morning. It is a presidential directive. It is classified. However, they indicated to me that they would be willing to make arrangements to provide the committee with that information and we will arrange with your staff, if that is agreeable, to have that happen.

Mr. NAGLE. OK.

Thank you, Mr. Chairman.

Thank you, gentlemen.

Mr. MYERS. Thank you.

Mr. NELSON. Mr. Nagle, I might say that since you have particular concerns which you have raised that are legitimate questions on the minds of a lot of people in the Congress, I can assure you that as long as this member has the privilege of leading this committee, that we are going to have an open and fair discussion.

Should any actions occur in the future, the fact that this is a civilian space program that is brought under intense public scrutiny, I would think and I feel quite confident that we will be able to ask those questions and get the answers that we need in the future, so that as a matter of governmental policy, whatever DOD activity is proposed, since it is on a civilian space station, that it would be with the clear approval of the Congress before that would occur.

As a practical matter, we are probably looking at any kind of activity not being decided for several years and then it being proposed, and I think that is going to have the clear daylight of scrutiny, which should enable us to confront and answer the policy questions you are raising, which are very good questions.

Mr. NAGLE. Mr. Chairman, if I may have your indulgence, I am not satisfied this morning. I am not satisfied that these discussions took place and we can't find out what the discussions were and we can't find out DOD's position. We are told that documents exist. Three weeks later members of the agency come back and say the documents don't exist. We are told that they were protracted nego-

tiations the first time we meet; now we find out this morning that they weren't.

We can't find out DOD's position, we can't find out NASA's position. We are asked to believe an agency the size of NASA went into negotiations over a mammoth document without any position papers or prepared anything in writing. I don't find it credible and I am not satisfied, Mr. Chairman, and with the Chairman's indulgence, as the opportunity presents itself I am going to pursue it.

Mr. NELSON. Well, I certainly want you to. You guys can see the kind of concern that is being expressed up here, and Mr. Nagle has stepped to the fore and has expressed that kind of concern, so that is going to be an ongoing concern that is going to be expressed.

Let me ask a couple of questions here. Look at page 5, Mr. Newman, of your presentation. Under fiscal year 1987, the minus $108 million for reductions in other programs, what does that include, please?

Mr. NEWMAN. We did outline that at the time of the budget amendment. It does include a reduction of $36 million, which we found possible because we had estimated less Air Force use of the Centaur residual activities than actually occurred. In other words, we overestimated the amount we would have to cover in connection with that termination because the Air Force used the hardware.

It includes $10 million which was taken out of the space transportation capability activities, largely the Spacelab, which was additional recognition of the impact of the delay of these future missions of Spacelab. It includes $18 million taken out of the science area, and primarily at that point out of the upper atmosphere research satellite because we recognize further reduction related to the delay of that satellite, that we could take that in fiscal year 1987. It included a proposed reduction of $10 million in the transatmospheric vehicle activity. Now, we have restored that. The Congress restored part of it and we have in the operating plan restored the rest of that.

Mr. NELSON. You are talking about the aerospace plane?

Mr. NEWMAN. Yes, sir. The technology to support the Aero-Space plane. I think Dr. Colladay briefed you some on that at the last hearing. It includes further reductions in the shuttle operations, and it includes a $10 million reduction that we took in tracking and data, and it includes the $15 million reduction in construction of facilities.

Mr. NELSON. Now that was the budget amendment that was submitted last fall?

Mr. NEWMAN. In August, as I remember it.

Mr. NELSON. OK. Now going down your list, down to ACTS, plus $77 million.

Mr. NEWMAN. Yes, sir.

Mr. NELSON. That was as a result of the appropriations of last year?

Mr. NEWMAN. That was included in the appropriation action in October, and we've actually programmed $85 million, because as we looked at it with the contractual status of that program, it made more sense to continue at that level.

Mr. NELSON. And how much of that $77 million increase in appropriation for ACTS has been spent and/or obligated toward ACTS today?

Mr. NEWMAN. Well, cumulatively, through Fiscal Year 1986, we had funded $152 million.

Mr. NELSON. Yes. That's not my question. My question is with regard to Fiscal Year 1987, in the money that was appropriated for ACTS, how much has been spent or is expected to be spent in 1987?

Mr. NEWMAN. Well, we expect to use essentially all of the 1985. We are running right now about $8 million a month. So we're four months into the year, and the figure would be on the order of $32 million of the 1985 has been applied to the program. I can check the exact number, but we're running about that rate.

Mr. NELSON. OK. $32 million of the $85 million that was appropriated for ACTS has been spent, and it has been spent for ACTS.

Mr. NEWMAN. Oh, it's all been applied to ACTS.

Mr. NELSON. All ACTS?

Mr. NEWMAN. Yes. I'd like to check the figure, but I'm going by the rate that I know we are applying to that program.

Mr. NELSON. OK. Excuse me one minute.

[Pause.]

Mr. NELSON. All right. If you're telling me that you intend to spend all of the money of the $85 million for ACTS, then why did NASA come forth with a proposed rescission to Congress not to spend that money for ACTS?

Mr. NEWMAN. I may have misspoken in this sense. The $85 million is totally programmed for ACTS. The proposed rescission, which was a policy-level decision that all rescissions previously proposed would be proposed again, the rescission was based on rescinding $26 million and leaving the balance in the program to cover phaseout of the program.

If Congress does not approve the rescission, then basically we are on a program that would use the $85 million. We are proceeding now at a rate consistent with using that $85 million and with the launch readiness sometime in 1990 or 1991, right about the end of 1990.

Mr. NELSON. Why did you—when was the rescission submitted?

Mr. NEWMAN. With the budget, January.

Mr. NELSON. Why did you propose—what's the verb—rescissing?—why did you propose the rescission when, in fact, you know the legislative intent of the Congress with regard to ACTS?

Mr. NEWMAN. We did request the ACTS funding in our 1988 request to OMB. The Administration made a policy-level decision that all rescissions previously proposed would be proposed again. And so we were directed to do that.

Mr. MYERS. And that included rescissions in many other departments.

Mr. NELSON. That's a great way to set policy. And fortunately, we're not going to let it be set that way, and we're not going to let OMB tell us what our space program ought to be. OMB certainly has a very important role, and we don't diminish that at all, but it is those kinds of things that, if they ever become policy, get us all fouled up.

But I don't need to preach to you all, because you're the choir on that regard.

OK. Let me ask you—where is that little note on the written report?

[Pause.]

Mr. NELSON. OK. We keep hearing about the Phillips Committee and the Phillips Report, and we have a bunch of Vu-graphs. But where's the written report?

Mr. MYERS. There was a summary made by General Phillips that covered the nine items that I discussed in the briefing today, a very thin summary, about a quarter of an inch. And that, plus the briefing material, is the sum total of the Phillips activity.

We are using that. We have one more thing that we have done since then. We have taken that report apart to identify the specific actions that we need to take to respond to the report, and we have that activity complete.

Mr. NELSON. OK. Here's what I think might be important. This might be helpful guidance to you.

Since so much importance is attached to the Phillips Report, and since indeed your comments today, talking about what you're doing, restructuring, streamlining, et cetera, are references back to the Phillips Report, I think that we need this thing clearly understood in writing, so that we have a basis from which to judge your progress or your detouring from the Phillips Reports.

Do you want to respond to that?

Mr. MYERS. I'm trying to think how to best do that. I wonder if the best way to do it wouldn't be to give you progress reports on the actions that we take as they occur, referencing his recommendation and then stating in writing the actions that NASA is taking.

It would seem to me that might be—because we're going to work on that basis; we're going to track this stuff. We've got actions out to all of our people. Each one that comes in, we're going to have a responding procedure or policy letter from my office or from Jim Fletcher. And it would seem to me that we could give you progress reports on our actions with respect to the Phillips Committee as one of the best ways we could show the responsiveness that we have to those.

Would that be acceptable, Mr. Chairman?

Mr. NELSON. What I don't want to be happening is, several years down the road, the answer to a question—"Oh, we did that, because that spun out of the Phillips recommendations"—and then nobody has any documentation that indeed that was what the Phillips—but these vague notions running around.

Now let me just give you a caveat for the future. Much has been made of Dr. Ride's proposed report. All right, now, I want, when you share with us what is the conclusion of that report, we want something concrete, in writing, so that as we work with you and sometimes nudging you to determine what should be the future goals of the American space program, that if you are making reference to a Ride Report, that we know specifically what that is, without some vague kind of connotation to it.

Mr. MYERS. Yes, I understand that.

Mr. NELSON. OK. So what do you want to do about Phillips, so that we've got that——

Mr. MYERS. I really think the Phillips Report would be best done by responding to you with the actions that we take, including the documentation that causes it to happen.

We have given you that summary report that gives you the broad overview of the recommendations. We've given you the briefing charts. Now we're taking the action to make that happen, and I think some type of progress report to you on the actions would be the best thing we could do to really give you not only the conclusions we've drawn, but what the heck have we done about it to make it happen. That seems to me to be what you'd be most interested in.

Mr. NELSON. All right. You use your best judgment. I don't want you to impose upon yourself something that's going to have you awash in paper. But one way or another, we need to document it. Either you can go back and have written the Phillips Report or do it the way you're talking about. But make it the simplest.

Mr. MYERS. All right.

Mr. NELSON. And the clearest.

Mr. MYERS. It's interesting. We thought the recommendations were very clear. We felt the briefing chart plus the summaries are clear recommendations to us. I'm a little disappointed that—maybe we worked so closely with Sam that we got a very strong feeling as to the clarity of his recommendations that may not come through in the briefing charts.

OK. We'll look at that and see what's the best way to keep the committee fully informed on our activities there.

Mr. NELSON. All right. I think that there is some ambiguity in the minds of our staff. So you might follow that up privately.

Mr. MYERS. OK.

Mr. NELSON. With the staff and make sure that those ambiguities are eliminated.

OK. We have another hearing, apparently, that wants to get in here, so we're going to adjourn this hearing. And let me remind the committee, how about calling the members for our organizational session at 3 o'clock this afternoon?

Thank you, gentlemen, for joining us today. Have a good day.

[Response to questions submitted to Mr. Myers from Chairman Nelson follows:]

Responses to Written Questions Submitted by Chrm. Nelson during the February 24, 1987, hearing.

## Overall Budget

QUESTION A-1a:

How will you pay for the shortfall in Research and Program Management funds in FY 1987?

Do you expect to be requesting any supplemental appropriations?

ANSWER A-1a:

The current plan to fund the shortfall in Research and Program Management due to increased pay costs and the Federal Employees Retirement System is to transfer funds from the Research and Development and Space Flight, Control and Data Communications appropriations.

There are no plans at the time to initiate a NASA request for supplemental appropriations.

## Reimbursable Funds

QUESTION A-2a&b:

What has been the total spending power of NASA over the past three years including both appropriated and reimbursable funds?

What percent of the NASA budget would you say reimburseable funds constitute?

ANSWER A-2a&b:

The following chart contains the appropriated amounts for NASA for FY 1985 through FY 1987 and the amount of reimbursements received by the agency for those three years. It should be noted that the term "total spending power" is a misnomer since all reimbursements are spent at the request of other entities to meet their requirements using funds provided by them.

| | (Dollars in Millions) FY 1985 | FY 1986 | FY 1987 |
|---|---|---|---|
| Appropriations | 7,552 | 7,764 | 10,534 |
| Replacement Orbiter | | | 2,100 |
| Other NASA Activities | | | 8,435 |
| Total Reimbursements | 1,821 | 1,859 | 1,184 |
| TOTAL | 9,373 | 9,623 | 11,718 |
| Reimbursements as percent of NASA Total | 19.4 | 19.6 | 9.7 |

QUESTION A-2c:

What portions of these reimbursable funds would you say are "pass through" (i.e. funds received from other agencies and directed toward a third party contractor)?

ANSWER A-2c:

The overwhelming majority of NASA's reimbursable activity is the result of agency's requesting NASA to perform work as a result of the other agency's requirements. Funds received for this work are considered "pass through" reimbursements, and the level of pass through reimbursements is contained in the chart below:

FY 1985 - $1008 million
FY 1986 - $1087 million
FY 1987 - $ 681 million

The pass through reimbursements do not include reimbursements for cooperative projects in which NASA is a partner. Examples of these projects are joint aeronautics projects with DOD, spacecraft procurement work for NOAA and reimbursements for Shuttle flights.

QUESTION A-2d:

How did you budget for the Delta Rocket for the COBE Mission and what role did reimbursable funds from the Palapa launch play?

ANSWER A-2d:

The Delta launch vehicle for the COBE mission is being funded by reimbursements for replacing NASA owned residual vehicle hardware sold to other users. $10.4 million of the reimbursements received from Indonesia for the Palapa launch is to replace this residual hardware.

Phillips Committee Recommendations

QUESTION A-3a:

Please explain briefly what organizational changes you intend to make as a result of the Phillips Committee recommendations which you sponsored.

ANSWER 3a:

The organizational changes already made or in process as a result of the Phillips Committee recommendations include:

1. Establishment of two new Associate Deputy Administrator positions to assist the Administrator and Deputy Administrator in carrying out their functions. The ADA-Policy will assist them primarily in the policy, planning, external affairs, communications, and related areas. The ADA-Institution will assist them in the management of NASA as an institution, including personnel, facilities, administration, and related areas.

2. The establishment of a policy and planning support staff headed by a new Associate Administrator for Policy and Planning. This office will provide central support for NASA planning activities and policy studies.

3. The establishment of an Office of Space Operation headed by a new Associate Administrator for Space Operations. This office is now responsible for reviewing all aspects of NASA's space operations, with initial emphasis on manned space flight operations, and for preparing plans for a possible future decision to consolidate some or all of NASA space operations under the AA-Space Operations. The Office of Space Tracking and Data Systems has become an element of the new Office of Space Operations.

4. The Associate Administrator for External Relations has been given responsibility for the Office of Legislative Affairs to strengthen and improve coordination of NASA efforts in this important field.

5. In addition, there have been second level organizational changes to carry out the Phillips Committee recommendations to move the management of multi-center programs (e.g. Shuttle and Space Station) from a lead center to NASA Headquarters

QUESTION A-3b:

When do you plan to split the Shuttle program into "operations" and "development"?

ANSWER A-3b:

The Office of Flight has already established a Director of Operations within the Space Shuttle program office to assure proper management attention to operations during the shuttle recovery period in which it is important that development and operations activities be closely linked.

QUESTION A-3c:

When do you envision consolidating the Space Shuttle and the Space Station operations activities under a single head?

ANSWER 3c:

We expect to consolidate Space Shuttle and Space Station activities under the Associate Administrator for Space Operations when space shuttle recovery is judged by the Administrator to be complete, as recommended in the Phillips Committee report. The timing of this decision will also depend on the results of the studies being initiated by the AA-Space Operations and the status of the Space Station program when shuttle recovery is complete.

QUESTION A-3d:

In view of the Phillips Committee recommendations how will you manage the next major space initiative (i.e. will you try to involve

many centers like the Space Station, will you try to have a lead center like the Shuttle Program, etc.)?

ANSWER 3d:

This will depend on the nature and content of the initiative. We will follow the advice of the Phillips Committee recommendation to avoid multi-center programs, if possible. However, a truly major initiative will most likely require significant involvement of several centers. In that case we would not have a lead center but have the program director and his staff manage the program from NASA Headquarters, as recommended in the Phillips Report.

QUESTION A-4:

What type of policy legislation will NASA be requesting in FY 1988?

ANSWER A-4:

The only legislative initiatives proposed by NASA for FY 1986 are contained in the proposed Authorization bill. Section 6 of the bill would amend the National Aeronautics and Space Act to provide NASA the authority to withhold from public disclosure certain technical data that are subject to control under the export control laws. This amendment is similar to authority which the Department of Defense was given in 1983. Section 7 of the bill would allow the Administrator to appoint up to fifteen retired military or civilian Federal employees without reducing their retired pay or regular pay. This will enable NASA to employ some key experienced personnel in executive positions to asset in the recovery from the Challenger accident and to staff up the Space Station reorganization.

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Mr. MYERS. Thank you very much.
Mr. NELSON. The meeting is adjourned.
[Whereupon, at 12:41 p.m., the hearing was concluded.]

# 1988 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 25, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 1:13 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good afternoon. Now I understand, Mr. Stofan and Mr. Aller, it's all right if we switch you on the program so that Mr. Aller's going first; is that correct? You've got a meeting that you need to go to.

Mr. ALLER. Yes.

Mr. NELSON. Okay. Well, today we're going to continue our series of hearings—I see some folks needs some chairs. Are there any chairs back there? If you've got an opening—all right, there's two. Would a couple of you come on over there? Why don't the rest of you, please just come on up and have a seat right up here?

We have an exciting set of testimonies today and some interest in this subject. So we appreciate all of you coming today, and I think it's going to be a productive session.

Now we're going to receive testimony from the NASA managers responsible for the newly established Office of Space Operations and also the Office for the Space Station. Obviously both of these are of particular critical importance to us. This committee has supported the space station initiative and that concept that there be a permanent presence of the United States in space, and that that is a necessary and worthwhile next step for us to take utilizing the space shuttle transportation system.

Now we also recognize that this next step is a little bit different than anything that NASA's done in the past. We're not going to be able to do, as we did in Apollo, of launch and recover and that's it. What happens with the space station when it's activated, then you're committed to around-the-clock operations.

So you hear on the tip of people's tongues the phrase, permanently manned space station, but there's a lot less talk about the permanently manned ground control centers, and the permanently manned payload processing and logistics facilities and all the other things that you have to do on a continuing basis to support that space station. So you see, it starts to be a little bit different mission from the kind of thing that NASA has done in the past.

Now needless to say, you've heard Mr. Walker's comments from yesterday, you've heard my comments and we're not satisfied that

sufficient progress has been made in defining that part of the program.

Now on the other hand, today we're going to hear right from the horse's mouth, from Dr. Stofan who runs that office of space operations. And we hope that his—well, I said space operations. I meant, we're going to hear directly from him on his Office of the Space Station. We're going to hear from Mr. Aller on his Office of Space Operations. And this is a new organizational identity, and it signals that the agency is in fact moving in the right direction to emphasize and give attention to these new operational responsibilities.

We heard yesterday that it might be as much as $1 billion a year just to operate the space station. So in trying to drive down the cost of operations, Mr. Aller is going to be in a unique position. And his goal is going to be completely contrary to what every other manager in the federal government's goal is. And that is, your goal is going to be to bring down your budget to the smallest possible budget.

So in holding these hearings we recognize that we are facing some uncertainty here with regard to the space station. The cost and schedule are now under review, and we're looking forward to finding out when we might have some of the results released.

Now last year we waited over six months for space policymaking groups in the Administration to make up their minds on a replacement orbiter. The situation was finally resolved by Congressional action. Now we're simply not going to wait around like that again.

Now unfortunately, what we find out is that a lot of the situation that had ground to a halt around and about the National Security Council, we see why now, that they had their minds on other things. But the fact is, that every American in this country expects us to have nothing less than the best space program, and we're not going to wait around again.

So I hope the witnesses can speak candidly about their programs, so that this Congress can make informed decisions as we mark up the NASA authorization bill for fiscal '88. And that mark-up is going to occur on March 26th.

So we're real pleased to have Mr. Stofan and Mr. Aller, and we will look forward to receiving your testimony.

Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. I once again would like to join you in extending a warm welcome to our witnesses today. Let me start off by telling our witnesses that there was a real lack of communication here yesterday. A number of my questions and many of the questions of other members were not adequately responded to in that session.

You should fully realize that the people of Pennsylvania did not send me here to sign blank checks. I doubt that any other member cares to do that either. This year we're being asked to provide $767 million for the space station. This is a project that we all want to support, but when we ask what you're going to do with the money we're told, we don't know yet. We ask what it's all going to cost, we're told, we can't discuss that. And we ask about figures in the notorious OMB memorandum, we're told, we can't comment on

those, despite the fact that I've already been contacted by members of the media who have copies of that memo.

I have one ironclad rule, and that is, I will not vote to fund a project that I don't fully understand. Despite more than two years of asking for questions on the cost of construction and operation, and despite more than two years of asking questions on the roles and missions of this proposed space station, I feel strongly that this committee has still not received the right answers. And until I receive satisfactory answers to those questions, I will not be able to decide if this project merits our support.

Let me repeat what I said yesterday. NASA must define the mission for the station and adequately address the questions of construction and operational costs. In all honesty, I have yet to see sufficient justification to move forward with an $8 billion station, let alone a $14 billion or a $20 billion station that NASA and OMB now apparently as discussing.

So far there seems to be a lot of smoke around this discussion, and I think it's time to speak frankly. We need to know why projected costs have doubled even before we've started construction. We need to know why do we keep changing the way we account for the funding of this project so that the cost growth does not look as large as it really is. We need to know exactly what is included in the station baseline and how that has changed over the past few years.

I want to see this nation move forward aggressively on a broad front on space programs. We need a healthy and robust civilian program. We need a strong space based national defense program. And we need to create the opportunity for the private sector to become fully involved in the creation of a space infrastructure that will support our spaced based economy of the future.

We need long term national goals, such as permanently manned colonies on the moon and on Mars. We need to create an aggressive program that will explore the universe. And we need to build a long term public support for funding that this overall program needs so that we have the adequate levels of support.

At the present time, we have a gross national product of a little under $4 trillion a year. Our present overall space program is a little under 1 percent of GNP. What we must be doing here is building public support for doubling that effort to a 2 percent of gross national product.

In order to do that, we've got to have the right answers. This subcommittee deserves the right answers and I hope today we begin to get them. Thank you very much, Mr. Chairman.

Mr. NELSON. Okay, would the folks standing please come on up and fill up these seats and then we will proceed? If you have a vacant seat by you, please raise your hand. Okay, you folks in the back, here are four seats right here.

This reminds me of the time when we were having a hearing on international competition to our commercial satellite launches. And you remember, that was the day that I had invited over the delegation from the People's Republic of China and they arrived and there was not a seat in the place. So I had them coming up here and the television cameras are whirring, and here we're having this on international competition with the United States,

and here's the whole delegation from the PRC sitting right here. [Laughter.]

Mr. NELSON. Okay, Mr. Aller.

**STATEMENT OF ROBERT O. ALLER, ASSOCIATE ADMINISTRATOR FOR SPACE OPERATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY CHARLES FORCE, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE OPERATIONS, AND RONALD DAPICE, DIRECTOR OF ADMINISTRATION, AND RESOURCES MANAGEMENT**

Mr. ALLER. Mr. Chairman and members of the subcommittee, it's a pleasure to be here again this year to present to you our budget request, principally for tracking and data systems for the fiscal year 1988, and ask for your support of that budget.

I have with me today Mr. Charles Force, a new deputy in the Office of Space Operations to my left. Mr. Ron Dapice, the director of resources and administration in the office.

With your permission, Mr. Chairman, I'll submit my written statement for the record and proceed with an informal discussion using the viewgraphs, if I may.

Mr. NELSON. All right.

Mr. ALLER. I might say, perhaps my testimony should go rather quickly in view of the comments and interest on the Space Station program, per se.

First slide, please. (Figure 1.)

Mr. NELSON. You don't think you're going to get off easy, do you?

Mr. WALKER. Nice try. [Laughter.]

Mr. ALLER. After those introductory comments of yours, I was ready to offer my seat to——

Mr. NELSON. Or to tell us that your meeting had started five minutes ago.

Mr. ALLER. What I hope to cover for you today as shown in figure 1 are the highlights of what's in the FY 1988 budget as well as mentioning the organizational change that you have mentioned in your introductory remarks, talk about what we've done through 1986 looking at the budget and program elements, and a short summary.

Could I have the next chart (figure 2), please? I believe this chart was shown to you yesterday. This is the new NASA organization. And the only comment I have is on the lower right, your right, is the Office of Space Operations. Up until January that was the Office of Space Tracking and Data. What has been done by Dr. Fletcher and Mr. Myers is to add the additional responsibility at this point of laying out a comprehensible plan for consolidation of space operations. This plan is to take effect after the recovery of the shuttle program.

Next chart (figure 3), please.

To accommodate that change, I have simply added an organization, Space Operations Planning. We're just in the process of putting that organization together. And over the next several months we will conduct the planning associated with the various operations in NASA.

I should comment briefly on space operations as I see it at this time. In NASA we have operations at several centers. Most of the discussion here today has been on manned operations. Now I'd like to comment that as far as logistics for long term operations, and maintaining long term operations, we've done that over the years in the unmanned program.

We've done it currently on one of the programs that I'll be talking about today, which is the TDRSS program. That certainly involves all the elements of a long term operation and the ground activities that are necessary to support that kind of a program.

And you're absolutely right, Mr. Chairman, to operate the complexity of something like the Space Station in the mid-1990's is a very large operation and will be an expensive operation and one that needs to be managed very effectively in that timeframe. And we're looking forward to that challenge.

Mr. NELSON. And that's going to be handled in your bailiwick, the operation of the station?

Mr. ALLER. The operation itself will be handled in space operations as we see it today. There are no functional statements that state at this point in time what activities we're going to migrate into space operations from the programs. For 30 years, as I believe the subcommittee is aware, our operations have been funded and handled principally out of the programs, both unmanned and manned.

Mr. NELSON. So right now worrying about the cost of operations is Mr. Stofan's worry, not your worry?

Mr. ALLER. I think it's both our worries, sir.

Mr. NELSON. Okay. You didn't let yourself out on that one.

Mr. ALLER. At this time I cannot contribute a great deal to the activities associated with operations in that timeframe, but I'm certainly going to be very much involved over the next few years. I've used this chart (figure 4) again to show the subcommittee what are the elements we talk about in tracking and data. And I should also mention that tracking and data is the only purely operational organization NASA has today. It's been operational for almost 30 years. We're operating seven days a week, 24 hours a day. So the elements of long term operation have been incorporated in NASA for some time.

The activities are displayed on this chart. Starting at the deep space, space probes, the low earth orbit, the balloon and the research programs, we're a support organization. But it covers the spectrum of activities ongoing in NASA as well as the aeronautics program with tracking, mission control, data handling, and communications.

Next slide (figure 5), please. Our major program objective—I'm sorry, I don't have the objective on the final bullet that says, develop a comprehensive plan for space operations"at a very cost effective manner." That's certainly part of it Mr. Chairman, as the cost can very quickly get out of hand in long term operations.

But our primary goal over the past several years has been the first bullet on that particular chart which is to provide responsive cost effective tracking and data systems.

Associated with that in the near term has been the need to assure continuity of the space network. The space network is the

network made up of Tracking and Data Relay Satellites where we have effectively moved our tracking stations from the ground into orbit.

As you know, we suffered another setback last January with the loss of the TDRS on the Challenger and we've had to proceed with additional spacecraft to replace that. Provide support via the ground network until the space network is fully operational. Also we've had on our plan closing many of the facilities we've funded over the years. We've had those plans since 1983 when we launched the first of the space network elements. Because of problems associated with getting the additional spacecraft into orbit, we've had to maintain that network.

We're expanding our capability to support the deep space missions, the very highly scientific missions that NASA conducts with the Deep Space Network. We're continuing to conduct studies, and we're looking into the requirements associated with the Space Station era for operations. And that requires the tracking, the data systems, the communications and what I chose to call the space network interoperability with our partners in the space network. And I'll talk a little bit more about that later. But it's certainly one of our prime objectives as we look ahead to the mid 1990s.

And finally, to develop the plan for consolidation of space operations as I've previously mentions.

Next chart (figure 6), please.

In 1986 we started off the year on two notes, of course. One was a very high note with the successful encounter of the Voyager spacecraft with Uranus. The Deep Space Newwork was very deeply involved in that. We had taken major steps with the network with your help to expand our capability to support that mission.

We, of course, had the setback of the Challenger loss in January. That was immediately felt in the network itself in that our spacecraft was aboard the Challenger. And we've had to replan the program as a result of that, initiated planning for a replacement spacecraft, and have had to rephase the closure of the ground stations.

We've begun construction of our large antennas that you all have helped us fund in past years, and I will describe that briefly as we proceed.

Communications program developments were completed both in the operational network—that's our NASCOM or network that we maintain purely for operations—and in the administrative network that we set up out of the Marshall Space Flight Center. That came on board last year.

Orbit computation system, that's an example of our ongoing need from a logistics standpoint to maintain ground systems for operational purposes. What that represents is a replacement of a major computer system at Goddard that's involved in orbit determination and attitude determination.

The Hubble Space Telescope, one of our most exciting science programs to be launched in 1988, we've had ground activities associated with that. Those two facilities, one to capture the data and transfer it to the scientists, and one to control the spacecraft have been basically completed in our on-line testing with the Space Telescope.

And we've initiated our plans for the development of facilities associated with the Space Station itself.

Next chart (figure 7), please.

This is our request for 1988, along with the 1987 budget. The increase from $880 million to $967 million is principally in the Space Network. And the elements in the Space Network are associated with the replanning and the replacement of the TDRSS program.

Next slide (figure 8), please. In the Space Network in TDRSS, this chart that you're familiar with, describes the system that we're trying to establish an operational network with. It's three satellites on orbit that replace the ground network for tracking of low earth orbit vehicles. What we have in orbit presently is the one shown in green at 41 degrees west off the coast of South America. That is presently in orbit and tracking various satellites that NASA now has in orbit, and was tracking the Shuttle prior to the Shuttle stand-down.

What we're hoping to do in 1988 is to put the "yellow and red" satellites in orbit on the first and fourth shuttle launches.

Next chart (figure 9), please. For those of you that are not familiar with the tracking station in orbit, the only picture I have of the satellite itself is one on the ground. In this photo, it's a shot of the TDRS satellite on top of the IUS stage. The vehicle is carried into orbit aboard the shuttle which delivers the IUS and the TDRS satellite into low earth orbit. The IUS, which is in the white on the slide here, propels it then into geosynchronous orbit and separates from it at that point, and the satellite deploys then at geosynchronous orbit of 22,000 miles.

There's a very interesting display of this satellite fully deployed. The next time anyone visits the Air and Space Museum, we put one in last fall in the display right above the Apollo-Soyuz display in the museum. It's a full-scale deployed TDRS satellite. It's a beautiful satellite and I encourage everyone to look at that satellite when they have an opportunity.

Next slide (figure 10), please.

This is a picture of the major ground station NASA has been implementing over the last several years at White Sands, New Mexico. This again is an example of a long term operation, where we've had to logistically maintain operations over several years and will into the future. In this slide you see the three antennas that interface with the satellites in orbit. You see two smaller antennas in the upper left part of the photo. Those are the DOMSAT interfaces where we transmit the information from shuttle say, to Houston from this location.

Our second ground station that we're in the process of implementing is about three miles south in the valley, in the same valley as this ground station.

Next slide (figure 11), please.

The TDRS satellite that is in orbit is not a healthy satellite. It has not been healthy since it reached orbit in 1983 because of the problems we had in reaching orbit. And I won't go into those here today, but I believe you're basically familiar with the fact that that satellite has only 13 of 24 thrusters. We've lost one gyro. We're on the back-up pointing system for the large antenna.

We've had a K-band on one of our frequencies, which is a transmitting frequency that sends commands to satellites, has failed on one side of the satellite. On another frequency, the S-band frequency that we communicate regularly with the Shuttle as well as other users has also failed. That failed this year. Those are both diplexer failures, and I'll mention those briefly again—on one antenna. On the other antenna, we have an operable system at both frequencies.

So that is not a healthy spacecraft. It's been in orbit four years now. And I will describe how we plan to replace that satellite with future launches. As I said before, the second TDRS was lost in January of '86.

Next slide (figure 12), please.

Very briefly, this is what's happened to that satellite, and it's very important because this is the payload side. We have basically a platform with payloads on it. The platform is the spacecraft, the payload is the radio frequency processing equipment that allows us to communicate with orbiting satellites.

We have a device aboard the satellite that's called a diplexer—the little box to your right—that permits us to transmit commands forward and receive the signals back from satellites, and transmit that data then on to the ground. That diplexer is what has failed on the one side, one of the large antennas. And that's what prevents us from transmitting forward.

The receive side of that diplexer is working. We can receive data from the spacecraft. We cannot transmit data to the spacecraft using one of our two antennas.

Next slide (figure 13), please.

This is our launch schedule to recover from the situation. Our third TDRS is to be launched in February of 1988, based on the present shuttle schedule. The fourth satellite will be launched in September of 1988. That's the fourth scheduled shuttle launch.

We plan to launch TDRS–5 as soon as we possibly can. And we're looking at various mechanisms by which we can get that satellite in orbit, both with the Shuttle as well as an expendable launch vehicle. And TDRS–6, the last of that string of spacecraft will be stored.

Next slide (figure 14), please.

Last year we initiated the replacement for the spacecraft we lost on Challenger. This spacecraft is very much needed. It was needed last year. It's needed even more now with the failures that have been suffered aboard the spacecraft in orbit.

To provide the continuity of that program, it's a two-phase program. We're putting together the requirements as they today exist. The problem of long-term operations is that many of the technologies aboard the existing six spacecraft have—we need to replace with the upcoming spacecraft, as well as some of the subcontractors are no longer producing the elements that were part of our first spacecraft.

So we're putting that information together now and we will begin procurement this year.

Next slide (figure 15).

The funding requirements for the Space Network, the TDRS program are displayed on this chart, and the request for 1988 is $481

million. That is where the growth in the entire program has occurred. Again, it's because of the procurement of the replacement spacecraft and the rescheduling of the entire TDRS program.

Mr. NELSON. Okay, let me stop you right there. We want you to proceed on with the policy questions now. Any additional items that you want to bring up. We can disgorge out of your written testimony the specifics of the budget request and so forth. Let's discuss any policy, and then we're going to move on.

Mr. ALLER. All right. Why don't I then, since we're moving on into Space Station, cover the two items I have that are related to Space Station and hit the summary of my presentation, if I may.

Mr. NELSON. Okay.

Mr. ALLER. Could I have—Ron, would you help find this chart, please?

Mr. NELSON. Just tell us what page. We're looking at it on our handouts.

Mr. ALLER. Figure 16.

Mr. NELSON. All right, proceed.

Mr. ALLER. That chart represents our planning as we're proceeding into the Space Station program from a ground systems tracking and data only standpoint. This budget, I must remind the subcommittee is a tracking and data systems budget. It does not represent space operations in the broader sense at this point in time. There is no funding in this budget for operations other than tracking and data.

So what I have here is the element that we're proceeding with in conjunction with the Space Station program, to provide those elements for operational capability that are needed for the Space Station program in the areas of data capture, communications and control.

Mr. NELSON. Okay, now what that chart doesn't tell us is, what data rate will the TDRS system support on the space station? What will be the average data rate that you will have coming from the station?

Mr. ALLER. I don't believe I or anyone else can answer the data rate yet, Mr. Chairman. The capability of TDRS is 300 megabits. Although I've heard data rates that are very high estimated from Space Station, I've not heard anything close to an average of 300 megabits.

Mr. NELSON. Well, do we think that two TDRS's up there with one as a back-up will service the space station?

Mr. ALLER. I'm certain that two with a back-up will service a Space Station. The situation, of course, is we will have many more satellites to service as well as Space Station. Both the Shuttle, the Space Telescope, our other free-flyers and any government free-flyers that we will support during that timeframe.

Mr. NELSON. Okay. Is the plan that you have outlined here for future TDRS's, will it service all of that?

Mr. ALLER. Yes, sir, it will, through the period of about 1995. Our plan is to continue with three in orbit until we reach the point the constraining factor for tracking from satellites are the two antennas we have on each satellite. We can only track, therefore, the higher data rate users—you need six of those. When we exceed

that capability, our plan is to put four TDRS satellites into orbit and expand our capability in that manner.

Mr. NELSON. All right.

Mr. ALLER. That's our present plan.

Mr. NELSON. In making that calculation, you must have an estimate of what your data rate is going to be.

Mr. ALLER. Well, the driving—yes, we have an estimate for Space Station itself. And the estimates that I am aware of range anywhere from about 20 megabits average to about 100 megabit average. That's over a 24-hour period. The peak rates will be up near the 300 megabits for a few moments. But the average rate should be well within 100 megabits.

We have users besides Station that are at the high user rate regime. LANDSAT, for instance, is 85 megabit. It certainly is not an average of that, but its peak rate when it's transmitting images is at 85 megabit.

So I believe the TDRSS program will handle the maximum data rates. It has been baselined. The program has been baselined to that. The constraining factor are the number of satellites in orbit.

Mr. NELSON. So at this point you're telling this committee that you're relatively confident that what you're planning for with three or possibly four TDRS is what we need to plan on budgeting for for the foreseeable future through 1995?

Mr. ALLER. Yes, sir, that's our plan today. Our plan for these satellites—let me give you our complete plan.

Mr. NELSON. I want to make sure that I understand your answer. My question was, is this what you think, and you answered, yes, sir, that is our plan today. I want to make sure that we have your personal stamp of approval that that's where we're going.

Mr. ALLER. My plan today is the one I just described, which is to provide one, possibly two additional spacecraft in the 1991-1992 timeframe—that's the replacement buy that was approved last year. We have initiated an advance program for TDRS at the same time those spacecraft are due to be available in the late 1996 timeframe.

It's keeping a logistics line of spacecraft available to meet the needs of the users in orbit. With four satellites in orbit and our predictions for what will exist in that timeframe in the approved programs, that will handle the requirements.

Mr. NELSON. Go ahead, Mr. Walker.

Mr. WALKER. Mr. Chairman, I want to start nailing down funding here.

Communications and data systems in budget is $210.3 million.

Mr. ALLER. Yes, sir.

Mr. WALKER. That includes the space station monies that you said were the operational costs for space station right now?

Mr. ALLER. No, sir. That includes in 1988 a very small our initially planning the capability to provide for Space Station.

Mr. WALKER. Okay, how much money is that?

Mr. ALLER. $4.5 million.

Mr. WALKER. $4.5 million.

Mr. ALLER. Yes, sir.

Mr. WALKER. So that accounts for most of the increase from the $205.5 in the 1987 budget to the $210.3——

Mr. ALLER. No, sir I can't account that $4 million to that. We've had 4 percent inflation—across the board 70 percent of our budget is operating budget, 15 percent roughly is to replace the TDRS system, and 15 percent is for systems development. The modest increase, I could account for it by the $4.5 million, but that is not the way I accounted for it.

Mr. WALKER. Okay, it's not—that's not the important point anyhow. How much money do you estimate it will cost on that line item on the budget when space station goes operational?

Mr. ALLER. Our estimate to complete that capability that I have shown here is approximately $360 million.

Mr. WALKER. Per year?

Mr. ALLER. No, sir, that's to provide the capability.

Mr. WALKER. All right. How much money is it going to cost us per year in the budget for operational cost of that system once the Space Station goes operational?

Mr. ALLER. Once the Space Station—I would only estimate. We have not calculated the operating cost of that facility. However, that facility is very comparable to the kinds of facilities we're operating today, and I would say it's within the $25 million per year operating cost.

Mr. WALKER. And the $360 million it's going to cost us to build the capability, that's spread out over how many years?

Mr. ALLER. I only have a run-out in front of me, sir, through 1992. The capability is to be on-line in 1993, compatible with Space Station.

Mr. WALKER. About a five-year spend out.

Mr. ALLER. The implementation really starts in 1989 at a very low number and runs out through 1993.

Mr. WALKER. About a four-year spend out then; an average of $90 million a year.

Mr. ALLER. I would say about 1990 through 1994, yes, sir.

Mr. WALKER. Thank you very much. Thank you, Mr. Chairman.

Mr. ALLER. Which is compatible with the current Space Station schedule.

Mr. WALKER. Thank you.

Mr. NELSON. Okay, why don't you go ahead and summarize and then we'll get any of the members that have questions.

Mr. ALLER. All right, let me comment on the next slide, if I might, because it is very much related to the Space Station era. No, I'm sorry, figure 17.

This is simply a sketch of what we are presently in the process of discussing with the Europeans and the Japanese. Both the Europeans and the Japanese plan to put up systems similar to the Tracking and Data Relay Satellite System. They're putting up their systems in conjunction with their activities on Space Station.

What I've depicted here is, what I call an international interoperable system that allows them to operate from their system and to communicate directly to us here in this country from both Europe and Japan. They have on their books plans for putting into orbit in the mid-'90s a data relay system. The Japanese plan to launch their prototype in 1991. I wanted to make the point that the Japanese launch in 1991 with their prototype.

Could I have the next chart (figure 18), please?

Mr. NELSON. Will that reduce the burden on our TDRS system?

Mr. ALLER. The reduced burden as I see it today, depending on how compatible these vehicles are, the Europeans and the Japanese today indicate they're going to operate at the KA-band and S-band, versus our KU-band and S-band. Now this is simply a different frequency regime, but we would not be compatible at the high data rate.

However, we would be compatible for our S-band users. For instance, space telescope operates at S-band. So from an operations standpoint I could see the capability where we could support, we could schedule through them and support a vehicle like Space Telescope via their S-band capability and process that data back from Europe or Japan to the users here in this country.

The advantage that would come to the system, as we all three see it today, is to make the entire tracking network more robust, and perhaps alleviate the need for on-orbit spares in our own case. But I want to emphasize we are planning our network to meet our needs. And I feel their contribution to meet their needs will be complementary to ours and that we will be able to utilize that capability.

Mr. NELSON. So the answer is no more than yes, which is that this system will not necessarily reduce the burden on our TDRS system.

Mr. ALLER. That's a more correct statement than to say that we will be able to alleviate the capability that we would maintain because of those systems.

Mr. NELSON. Are we trying to accommodate their national interest here?

Mr. ALLER. No, not at all. They made us aware of their planning on their satellites. Their satellites will be higher technology satellites than ours in that they're newer and the capability and technology is there. It will be a resource available to us.

I must point out, we use resources around the world today in our planetary program, and in our shuttle program in that we rely on the DOD systems. So I see it as an adjunct to our capacity. But I would not reduce our capacity in reliance on theirs.

Mr. NELSON. All right, please summarize and then we'll turn to the members.

Mr. ALLER. All right, in summary, the budget request is $967 million. That is the continued operation of the system and repayment of the TDRSS development loan. The first two items on that chart represent 70 percent of our budget. This will cover the TDRSS development and the replacement spacecraft and maintain the ground systems to accommodate the ongoing programs.

The increase from 1987 to 1988 is principally associated with the procurement of the replacement spacecraft, continued delay of the program and inflation of about $25 million. Much of our funding goes to manpower. We support roughly 5500 people in operations with our budget.

Next chart (figure 19), please.

Our major challenge has been, as we look ahead to 1988, are two successful (TDRS) launches, provide the capability and capacity to get the third satellite in orbit as soon as possible, support the space telescope, initiating the implementation of the second ground ter-

minal, maintaining an operational ground network, which is the network we hope to phase out to some degree, continue the preparation for the Space Station that we just discussed, and to consolidate, to plan for the consolidation of space operations. That ends my testimony.

[The prepared statement of Mr. Aller follows:]

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STATEMENT OF
ROBERT O. ALLER
ASSOCIATE ADMINISTRATOR FOR
SPACE OPERATIONS

National Aeronautics and Space Administration
before the
Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee: Thank you for this opportunity to present our FY 1988 budget request.

## INTRODUCTION AND HIGHLIGHTS

In a reorganization recently announced by NASA, the Administrator appointed me as the new Associate Administrator for Space Operations. To ensure increased management emphasis within NASA on space operations, I have been tasked with the responsibility to develop a plan for managing NASA's increasingly complex space operations, with initial priority to be given to manned-tended and manned-related space operations. The functions of Space Tracking and Data will become an integral part of Space Operations.

The FY 1988 budget which was submitted deals only with the functions of the space tracking and data systems program. The tracking and data systems program will continue to provide vital tracking, command, telemetry, communications, data relay, and data processing support to meet NASA flight program requirements. The transition from a ground based tracking network to a space based tracking capability for low earth orbital missions, which began with the TDRS-1, is continuing. Two additional TDRS spacecraft are scheduled for launch when Shuttle operations resume in 1988. TDRSS will be operational when three fully functioning spacecraft are in geosynchronous orbit, and the spacecraft and the ground systems have completed their individual and integrated acceptance tests.

The Challenger accident with the loss of TDRS-2 in 1986 interrupted preparation for support of agency missions and the deployment of the full three-spacecraft Tracking and Data Relay Satellite System. However, recovery efforts are underway with a procurement to replace the lost TDRS spacecraft as well as restructuring of the TDRS program in areas of development and spacecraft storage. The present ground tracking network is being

retained until attainment of an operational TDRSS. Reductions have been made in communications and data processing capacity during this period in which no Shuttle missions are being conducted.

In 1986, TDRS-1 continued to provide support services to Landsat 4 and 5, Earth Radiation Budget Satellite (ERBS), and Solar Mesosphere Explorer (SME). It also provided support in early 1986 to the Space Shuttle and the Solar Maximum Mission (SMM).

During 1986, using the Tracking and Data Relay Satellite in conjunction with large antennas in Japan and Australia, a capability was demonstrated to extend the baseline for Very Long Baseline Interferometry (VLBI) beyond an Earth diameter for the first time.

The Ground Networks, in 1986, supported both near-Earth orbiting satellites and deep space missions, as well as balloons, sounding rockets, and aeronautical flight test programs. The Spaceflight Tracking and Data Network (STDN) actively supported about a dozen missions including the Shuttle, Landsat, International Ultraviolet Explorer (IUE), Active Magnetospheric Particle Tracer Explorer (AMPTE), and Earth Radiation Budget Satellite (ERBS) programs. The Deep Space Network (DSN) had outstanding success in supporting the Voyager encounter of the planet Uranus, its rings, and its moons in late January 1986. The system delivered almost 500 images during the near encounter phase. This success was achieved by combining the received Voyager signals from all antennas at each station location, plus an external source in Australia. The DSN also supported the successful, international observation of Halley's Comet which included spacecraft from four different nations.

In the data systems area, major accomplishments in 1986 included operational control of nine orbiting spacecraft, development of facilities for launches of future spacecraft including the Hubble Space Telescope, Cosmic Background Explorer, Gamma Ray Observatory, and the Upper Atmosphere Research Satellite, as well as initiating plans to develop facilities for platform control, communications, and data capture for Space Station use.

The facilities being developed to support mission operations and to provide data capture and initial processing of scientific data for the Hubble Space Telescope were heavily involved throughout the year in end-to-end spacecraft testing. Verification of our systems interfaces and participation in the overall ground system operational verification will be major activities between now and launch.

A major development over the past several years in NASA's communications program, a Program Support Communications Network (PSCN), became operational in 1986. The PSCN is an integrated, digital network connecting NASA's installations, major

contractors, and universities and provides voice and data services to support the agency's institutional and programmatic requirements.

Having reviewed some of the major highlights of our program since our spring hearing, I will now turn to our budget request and the program challenges ahead.

FY 1988 BUDGET REQUEST

A total of $967 million is requested for FY 1988 to provide tracking, command, communications, data acquisition and data processing support to NASA flight missions. This includes $481.5 million for the Space Network Program; $257.1 million for the Ground Networks Program; $210.3 million for the Communications and Data Systems Program; and $18.1 million for the Advanced Systems Program.

These funds will be used to operate and maintain existing network and other support facilities, repay the TDRSS development loans, implement new support capabilities, and carry out studies and technology development for future support. Also included is the FY 1988 funding increment to procure a TDRS spacecraft to replace the one lost in the Challenger accident. Of the total amount requested, about 70% of the funds are required to operate and maintain existing support facilities and to repay the TDRSS development loans and 15% is for TDRSS development including the replacement spacecraft. The balance of approximately 15% is for ground support implementation and technology development to accommodate both ongoing and upcoming missions.

The increase from FY 1987 to FY 1988 is primarily attributable to the procurement of a TDRS replacement spacecraft, the continued delay of TDRSS with two launches scheduled for 1988, and inflation.

SPACE NETWORK

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and the associated NASA ground systems necessary to provide support services to low-Earth orbital spacecraft compatible with the TDRSS. The elements of this network are the Tracking and Data Relay Satellites and the White Sands Ground Terminal (WSGT) of the TDRSS, the Network Control Center (NCC), the Flight Dynamics Facility (FDF), the Simulations Operations Center (SOC), the Compatibility Test Vans (CTV), the Bilateration Ranging Transponder System (BRTS), and the NASA Ground Terminal (NGT) which is collocated with the WSGT in New Mexico.

The TDRSS satellites and the WSGT provide the communications between the ground and user spacecraft in both command (forward)

and telemetry and tracking (return) modes. Other elements of the network interconnect the ground control facilities of the user spacecraft with the TDRSS. Specifically, the NGT provides the communications interface to other facilities, monitors TDRSS performance and performs trouble shooting and system verification functions for the network. The NCC schedules TDRSS services for all users and serves as the focal point for user interaction with the network systems. The FDF provides orbit determination and time correlated position location for all Earth orbiters supported by the Space Network. The BRTS provides precision position location for the TDRSS satellites. The Simulations Operations Center and Compatibility Test Vans provide necessary testing, simulations, and interface verification for the user spacecraft and Space Network elements to assure operational readiness prior to the launch of a given mission.

During the past year, TDRS-1 in conjunction with the White Sands Ground Terminal has continued its support of missions in an outstanding manner although this aging spacecraft continues to degrade in its operational capacity. During the year, the spacecraft lost its capacity to transmit via the S-Band frequency on one of its single access antennas due to a failure of an S-Band diplexer. This failure along with previous failures reported to this subcommittee which include a gyro, 13 of 24 thrusters, Ku-Band forward links, command timing circuits, and the antenna control system have reduced the capability of TDRS-1. Without further degradation, it can continue to support mission requirements for Shuttle, Landsat-4 and -5, ERBS, SME and future spacecraft like the Hubble Space Telescope. Contingency plans have been developed, however, to provide limited ground network support to orbital spacecraft and Shuttle missions should TDRS-1 fail.

The program to provide the backup TDRS ground terminal has progressed very well during the year. System contractor selections are later this year. Facility implementation is underway with operational readiness planned for 1992.

The four remaining TDRS spacecraft are being modified to meet Shuttle safety requirements, reduce susceptibility of certain electronic components to cosmic ray hits, and to modify components associated with the failure modes observed on TDRS-1. TDRS-3 and -4 are undergoing final assembly, test, and launch preparations for their February and September 1988 scheduled flights. TDRS-5 will be prepared for launch. TDRS-6 will be completed and placed in storage until required for launch. The next TDRS to be launched will be positioned over the Pacific in the western position. The following spacecraft will replace the current spacecraft over the Atlantic and TDRS-1 will be moved to a central location as a spare to be replaced by TDRS-5 as early

as 1989 dependent upon launch availability. Due to the loss of TDRS-2, a replacement program was initiated this year to ensure continuity of service in the early 1990's. The replacement program plan provides for the acquisition of an additional spacecraft with delivery in 1991 with long lead components for a second replacement spacecraft, if required. The replacement spacecraft is functionally identical to the existing TDRS Spacecraft.

A program for the early studies of an advanced concept are underway with plans for the initial spacecraft in the late 1990's.

## GROUND NETWORKS

NASA maintains three ground tracking and data acquisition programs to provide support to its space and aeronautical activities. These programs are the Spaceflight Tracking and Data Network (STDN), the Deep Space Network (DSN), and the Aeronautics, Balloon, and Sounding Rocket (AB&SR) program.

## SPACEFLIGHT TRACKING AND DATA NETWORK (STDN)

During the hearings last spring, we indicated that the planned closure date for the STDN ground stations used for Earth orbital support had been extended until not earlier than June 1987, as a result of the Challenger accident and loss of TDRS-2. This date has been further extended into 1989. This extension is based on the current Shuttle manifest for launch of the next two TDRS spacecraft. Station phasedown criteria is based on attainment of an operational status by the TDRSS. We plan to close or transfer to other agencies the STDN stations at Ascension Island; Guam; Hawaii; Santiago, Chile; Dakar, Senegal; and the UHF voice station at Yarragadee, Australia. During the shuttle standdown, we placed the Dakar station in a caretaker status. It will be reactivated approximately five months before the first Shuttle flight to allow adequate testing. Currently, we are conducting once-a-month Shuttle training at each of our ground stations to maintain their STS proficiency and are continuing to support about a dozen missions.

During FY 1987 and 1988, we will operate the remaining STDN network and due to the need to extend these systems have initiated a modest program to replace old, unreliable electronics. In addition to the operation and maintenance of the extended STDN ground stations, our FY 1988 request also includes funds for the Networks Logistics Depot which will continue to provide spare parts and supplies to all the Space Tracking and Data Systems Networks, control centers, and associated facilities.

DEEP SPACE NETWORK (DSN)

The Deep Space Network is a worldwide multimission telecommunications system which supports a wide variety of Earth orbital, planetary and interplanetary spacecraft as well as ground based radar observations of the near planets, comets, and asteroids.

The DSN's major activity during 1986 was focused on the Voyager Spacecraft encounter of Uranus and various encounters of Halley's Comet by an international fleet of spacecraft. The Voyager support was provided by an upgraded network which combined spacecraft signals with those from a large radio science antenna in Australia.

The next major challenge for the DSN will be in 1989 when the Voyager spacecraft will encounter Neptune at a range of approximately three billion miles. In preparation for this event major modifications are underway at all DSN facilities to improve their sensitivity for the encounter with Neptune. The DSN is enlarging its 64-meter antennas to 70 meters and has completed construction of a high efficiency 34-meter antenna in Madrid. These improvements are among the many necessary enhancements required to gather imaging data from the planet. In order to obtain the signal we will also augment the DSN by "borrowing" the signal gathering capability of a number of large radio telescopes around the world. The National Science Foundation's Very Large Array in New Mexico (27 antennas) will add to our Goldstone Complex. Similarly, in Australia, the Parkes 64-meter observatory will add to the NASA Canberra's telemetry data reception capability as was done for the Uranus encounter. In addition, the Japanese Institute of Space and Astronautical Science's 64-meter antenna at Usuda, Japan, will be used to gather radio science data along with the Canberra facility.

During the 1988 timeframe we will be working toward support readiness for future planetary missions. Windows of opportunity exist for launching the Galileo, Ulysses, and Magellan missions in the 1989-1991 timeframe. Galileo and Magellan, as well as future spacecraft, will be supported in the higher X-band frequency in order to increase transmission reliability, efficiency, and tracking precision.

In the longer term, we are planning to use even higher telecommunications frequencies and thereby reap the benefits of even greater efficiency, reliability, and tracking precision. The 1988 CofF budget contains funds for implementation of a new 34-meter development antenna at Goldstone which will be completed in 1990. It will be used to develop a capability to operate the DSN in the K-band frequency range.

## COMMUNICATIONS AND DATA SYSTEMS

The basic elements of the Communications and Data Systems Program form the vital link between the data acquisition stations and the users and include communications, mission control, and data capture and processing.

### COMMUNICATIONS

The Space Tracking and Data Systems Communications Program provides communication services for the Agency-wide operational and non-operational administrative communications needs. The operational communications networks comprise almost 3 million miles of circuits with associated switching and terminal facilities. A global system interconnects NASA's foreign and domestic tracking and data acquisition stations, launch areas, mission and network control centers and NASA support installations.

In FY 1988, after a period of reduced capacity following the Challenger accident, the NASCOM operational network will be restored to its full complement of circuits for the resumption of Shuttle missions.

The Program Support Communications Network (PSCN) was implemented in FY 1986 to meet NASA's administrative and programmatic voice and data requirements. The PSCN connects NASA installations, major contractors, and university locations. To meet the increasing scientific data exchange requirements, the PSCN in FY 1987 and 1988 will provide expanded service to the science program and aerodynamic users.

### MISSION CONTROL

The Mission Facility Implementation Program provides the systems capability to command and control NASA's unmanned scientific and applications satellite program through Operations Control Centers and related Command Management Facilities. They receive, process, and display spacecraft telemetry data and transmit commands. The Command Management System interfaces with the scientific user community to generate mission plans and prepare command loads for uplink to the spacecraft. Currently, four control centers monitor and control some 9 spacecraft. Funds are required in FY 1988 to operate these control centers and supporting facilities for the control of on-orbit and future missions.

A fifth control center, the Hubble Space Telescope Control Center, has completed spacecraft operations tests with the fully assembled spacecraft on the ground in a simulated space environment and will support mission requirements. Software

developments are planned in FY 1988 which will provide more efficient use of the telescope observation programs.

Included in the FY 1988 request are funds for modification to the existing Multisatellite Operations Control Center (MSOCC) for control of the Gamma Ray Observatory (GRO), the Cosmic Background Explorer (COBE), and the Upper Atmosphere Research Satellite (UARS).

DATA PROCESSING

Two separate activities are funded within the Data Processing Program. These include processing of data acquired by the low earth orbiting spacecraft for both scientific and applications missions, and real time computation support of mission operations which includes attitude determination.

In FY 1988, there are funds to improve real-time computational support activities. Telemetry data processing support continues for the ongoing free flying NASA spacecraft such as the Dynamic Explorer (DE), the Earth Radiation Budget Satellite (ERBS), and the Interplanetary Monitoring Platform (IMP). Planning, operations, systems implementation, and testing will continue for support of new missions such as Cosmic Background Explorer, Gamma Ray Observatory, Upper Atmosphere Research Satellite, Hubble Space Telescope, future Spacelabs, ASTRO (attached Shuttle astronomy) series, ATLAS (Atmospheric Laboratory for Applications and Science) missions and the International Microgravity Laboratory (IML) flights.

SPACE STATION

Funds are provided in the FY 1988 budget which will continue conceptual configuration studies to provide for platform control, communications, and data capture and distribution for Space Station use.

We plan to continue our discussion with the European Space Agency and NASDA to define studies and future implementation of compatible network, communication, and control systems.

ADVANCED SYSTEMS

With a small but essential Advanced Systems program, we will continue to accomplish the early developments and demonstrations directly applicable to systems planning with the objective of assuring more efficient and cost-effective mission support in the future. Before making major systems augmentations and

implementing newly required support capabilities, we must assess the technical alternatives, make trade-off studies and develop the necessary critical technology. The Advanced Systems program will continue to examine technology advances, particularly in telecommunications, microelectronics and automation for application to our future program needs. Studies and developments are continuing in order to extend our spacecraft-to-ground telecommunications capabilities. Better methods and techniques are being examined for processing, distributing, and storing the ever increasing amounts of data acquired from missions. New methods of control are needed in an era of increasing demand for remote, interactive mission and experiment control.

## CONCLUSION

In summary, the $967 million requested in FY 1988 provides the resources necessary to meet support requirements for the Space Tracking and Data Systems program. We are continuing to transition from a ground tracking network to a space tracking capability with the launch in 1988 of the next two Tracking and Data Relay Satellites. We will continue the phasedown of ground stations when the TDRSS is considered operational. Our system will continue with additions and modifications to meet our current and future program requirements.

Mr. Chairman and members of the Subcommittee, this concludes my statement. Thank you for this opportunity to discuss NASA's Space Tracking and Data Systems Program. I urge the full support of the Subcommittee for our FY 1988 budget request.

Thank you.

GRAPHICS TO ACCOMPANY

STATEMENT OF

# ROBERT O. ALLER

ASSOCIATE ADMINISTRATOR FOR SPACE OPERATIONS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

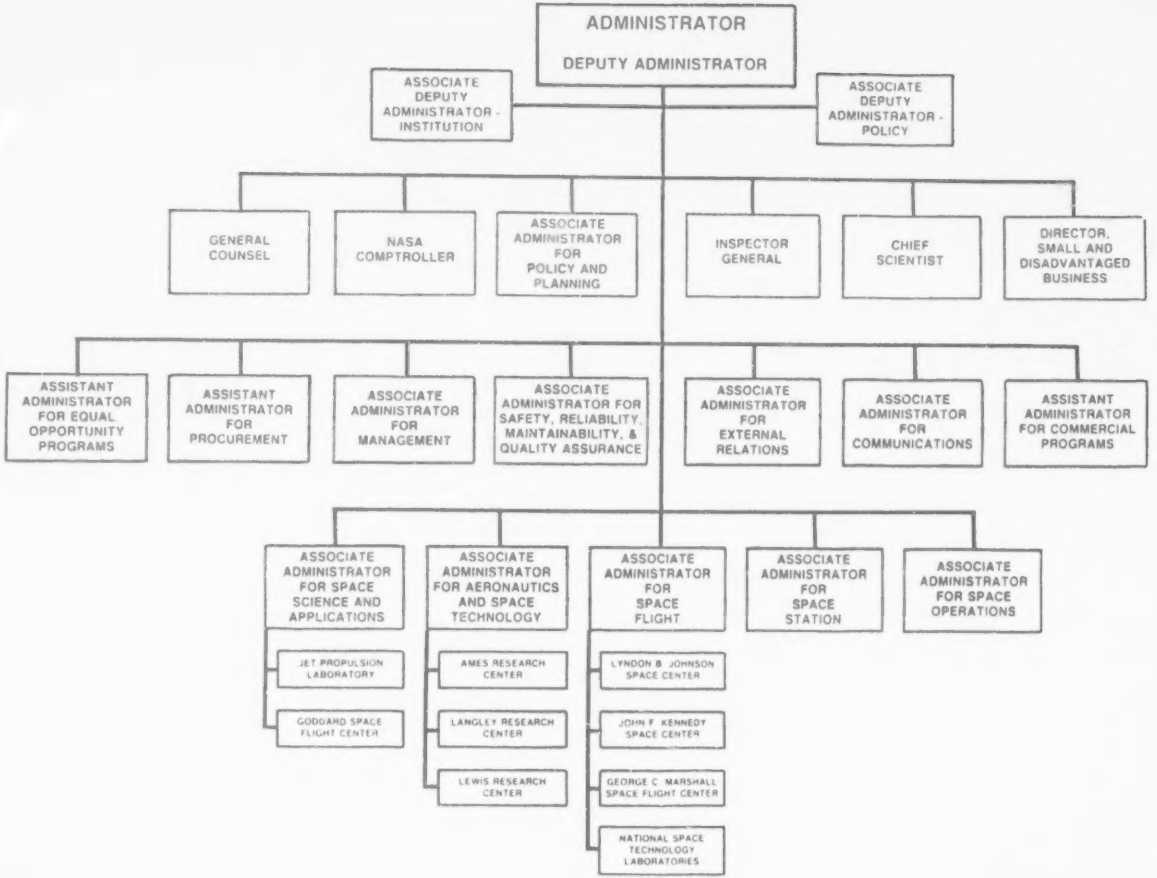
FEBRUARY 25, 1987

# OFFICE OF SPACE OPERATIONS
# PRESENTATION OUTLINE

- ORGANIZATION
- FUNCTIONS
- MAJOR PROGRAM OBJECTIVES
- 1986 HIGHLIGHTS/MAJOR EVENTS
- 1988 BUDGET
- PROGRAM ELEMENTS
- SUMMARY



Figure 1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DEPUTY ADMINISTRATOR
ASSOCIATE DEPUTY ADMINISTRATOR - INSTITUTION
ASSOCIATE DEPUTY ADMINISTRATOR - POLICY
GENERAL COUNSEL
NASA COMPTROLLER
ASSOCIATE ADMINISTRATOR FOR POLICY AND PLANNING
INSPECTOR GENERAL
CHIEF SCIENTIST
DIRECTOR, SMALL AND DISADVANTAGED BUSINESS
ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS
ASSISTANT ADMINISTRATOR FOR PROCUREMENT
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT
ASSOCIATE ADMINISTRATOR FOR SAFETY, RELIABILITY, MAINTAINABILITY, & QUALITY ASSURANCE
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE ADMINISTRATOR FOR COMMUNICATIONS
ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE STATION
ASSOCIATE ADMINISTRATOR FOR SPACE OPERATIONS

Figure 2

# Office of Space Operations

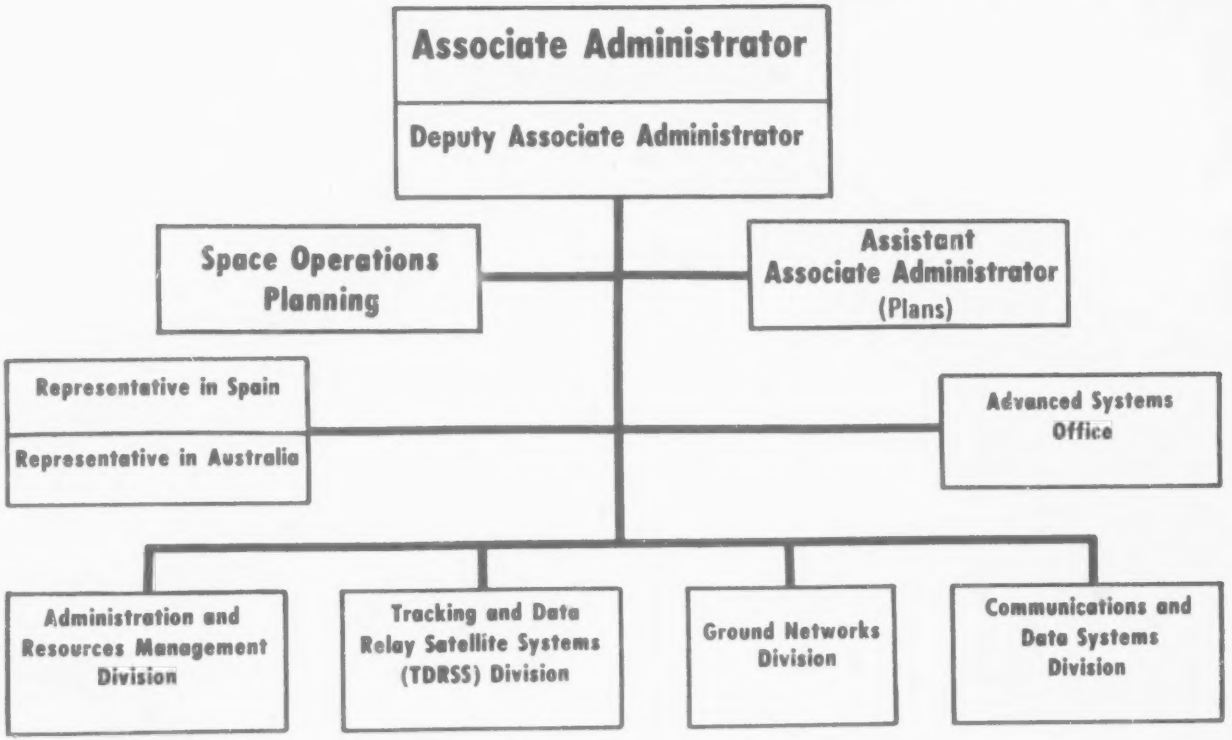



Figure 3

# TRACKING AND DATA ACQUISITION FUNCTIONS

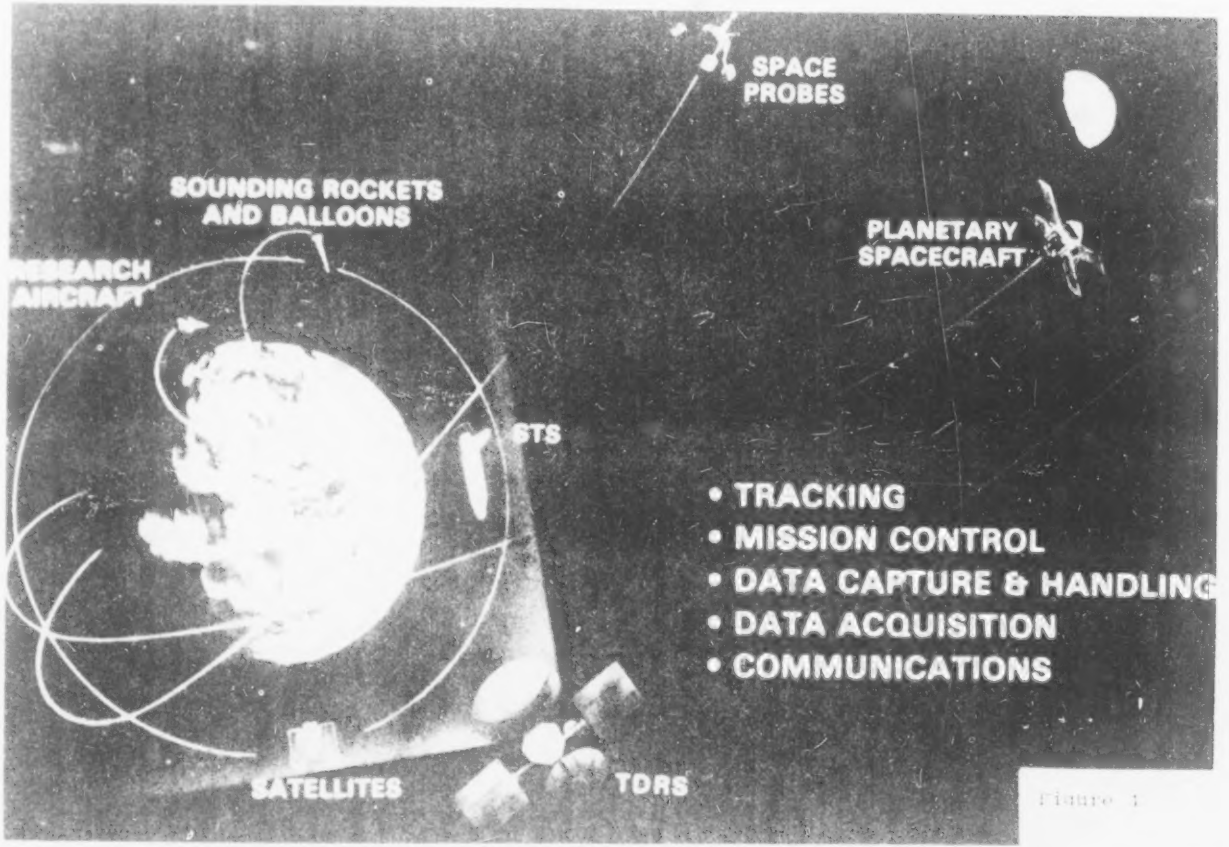



Figure 1

OFFICE OF SPACE OPERATIONS

# MAJOR PROGRAM OBJECTIVES

- PROVIDE RESPONSIVE, COST-EFFECTIVE TRACKING AND DATA SYSTEMS SUPPORT TO ONGOING AND APPROVED MISSIONS
  - ASSURE CONTINUITY OF THE SPACE NETWORK FOR SUPPORT OF EARTH ORBITING MISSIONS
  - PROVIDE SUPPORT VIA THE GROUND NETWORK UNTIL SPACE NETWORK IS FULLY OPERATIONAL
  - EXTEND THE CAPABILITIES OF THE GROUND NETWORK TO MEET DEEP SPACE MISSION SUPPORT REQUIREMENTS: ARRAYING, X-BAND UPLINK
- CONDUCT STUDIES AND DEVELOPMENTS AIMED AT NEW OR IMPROVED SUPPORT OF FUTURE MISSIONS
- ASSURE T&DS CAPABILITIES FOR SUPPORT IN THE SPACE STATION ERA
  - SPACE NETWORK
  - DATA SYSTEMS AND DATA STANDARDS
  - COMMUNICATIONS
  - SPACE NETWORK INTEROPERABILITY
- DEVELOP COMPREHENSIVE PLAN FOR SPACE OPERATIONS



Figure 5

# 1986 MAJOR EVENTS

- DSN SUPPORTED
  - — VOYAGER URANUS ENCOUNTER
  - — GIOTTO, PATHFINDER/HALLEY'S COMET
- LOSS OF TDRS-2 IN STS-51L ACCIDENT
  - — REPLANNED TDRS PROGRAM
  - — INITIATED PLANNING FOR PROCUREMENT OF REPLACEMENT SPACECRAFT
  - — REPLANNED PHASEOUT OF STDN GROUND NETWORK
- BEGAN CONSTRUCTION OF 64-70 METER ANTENNA CONVERSION PROGRAM
- COMMUNICATIONS PROGRAM DEVELOPMENTS COMPLETED
  - TIME DIVISION MULTIPLE ACCESS (TDMA)
  - PROGRAM SUPPORT COMMUNICATIONS NETWORK (PSCN)
- ORBIT COMPUTATION SYSTEM (OCS) REPLACEMENT PROGRAM COMPLETED
- HUBBLE SPACE TELESCOPE:
  - CONTROL CENTER COMPLETED SPACECRAFT OPERATIONS TESTS WITH FULLY ASSEMBLED SPACECRAFT IN SIMULATED SPACE ENVIRONMENT
  - COMPLETED DATA CAPTURE FACILITY DURING SHUTTLE STANDDOWN TESTING AND DATA FLOW ACTIVITY
- INITIATED DEVELOPMENT PLANS FOR SPACE STATION PLATFORMS COMMAND AND CONTROL, COMMUNICATIONS AND DATA PROCESSING

Figure 6

# SPACE TRACKING AND DATA SYSTEMS PROGRAM

## FUNDING REQUIREMENTS (IN MILLIONS OF DOLLARS)

| | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|
| **SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS** | | |
| • SPACE NETWORK | $407.3 | $481.5 |
| • GROUND NETWORK | 250.1 | 257.1 |
| • COMMUNICATIONS AND DATA SYSTEMS | 205.5 | 210.3 |
| SUB-TOTAL | $862.9 | $948.9 |
| **RESEARCH AND DEVELOPMENT** | | |
| • ADVANCED SYSTEMS | $ 17.1 | $ 18.1 |
| TOTAL | $880.0 | $967.0 |

Figure 7

# TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

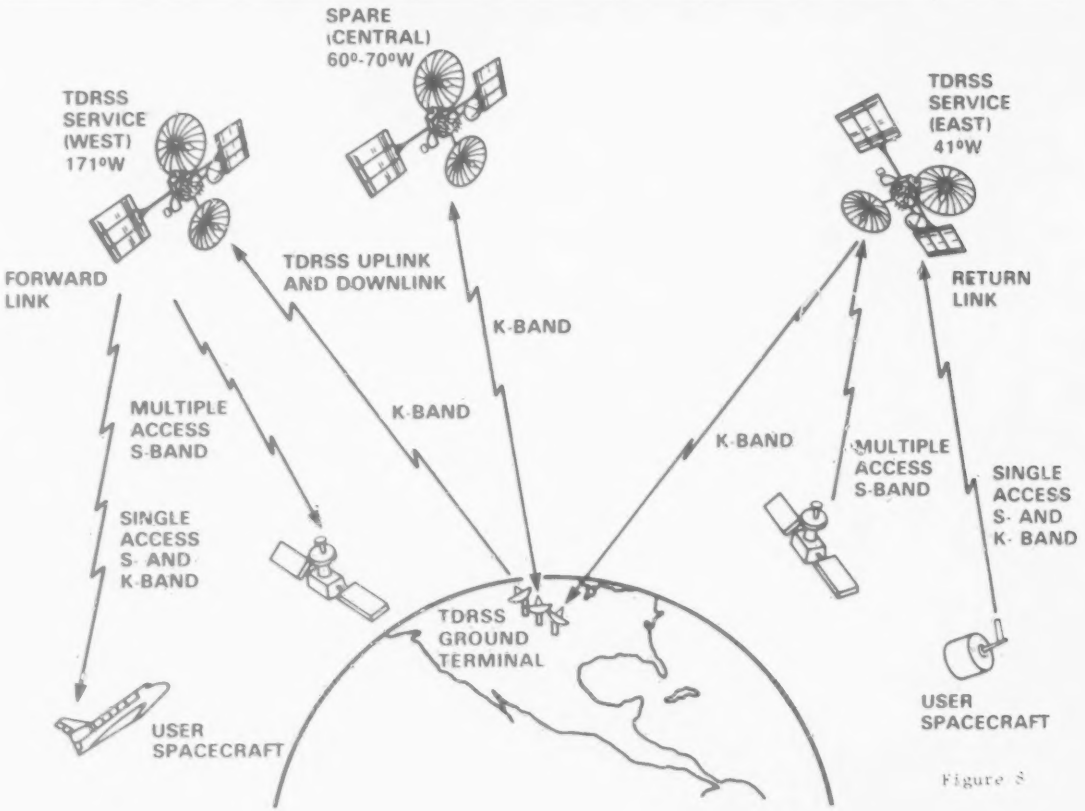
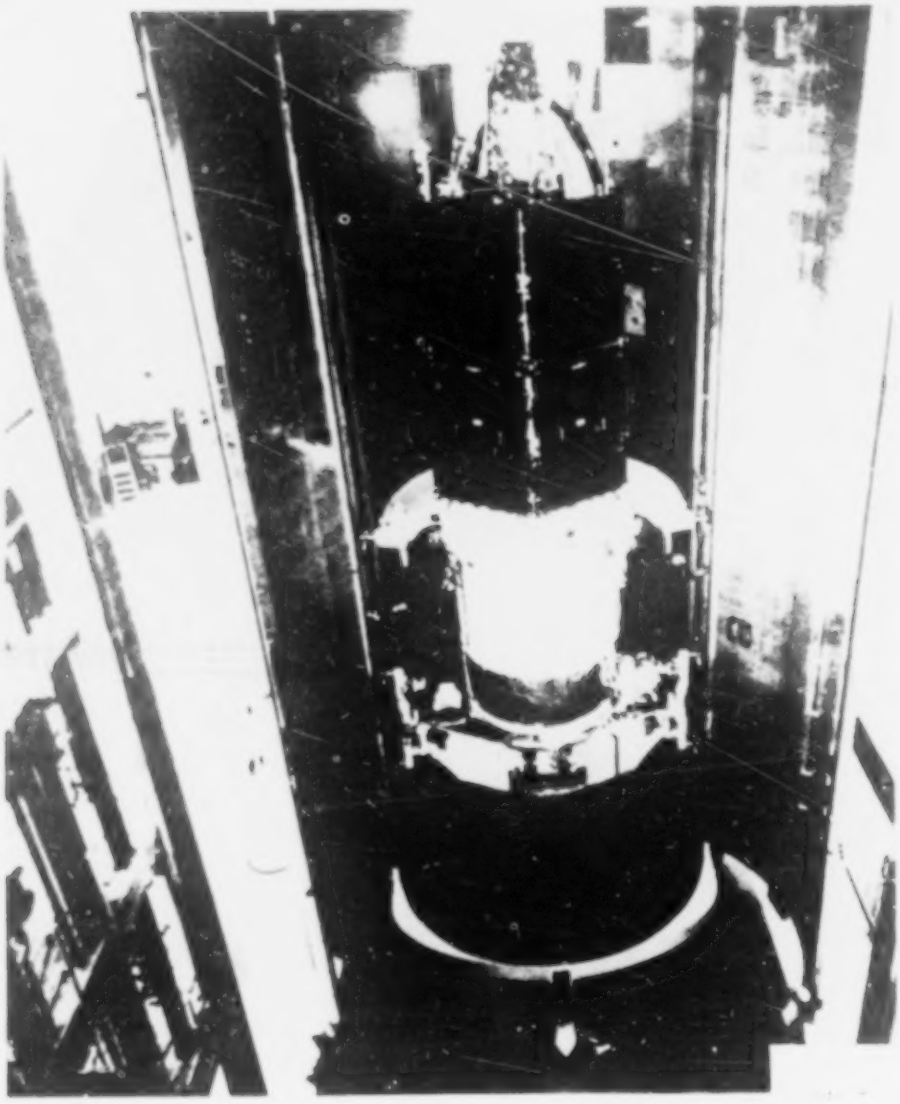



Figure 8



TDRS-A ASSEMBLED WITH IUS

TDRSS GROUND STATION
WHITE SANDS, NEW MEXICO

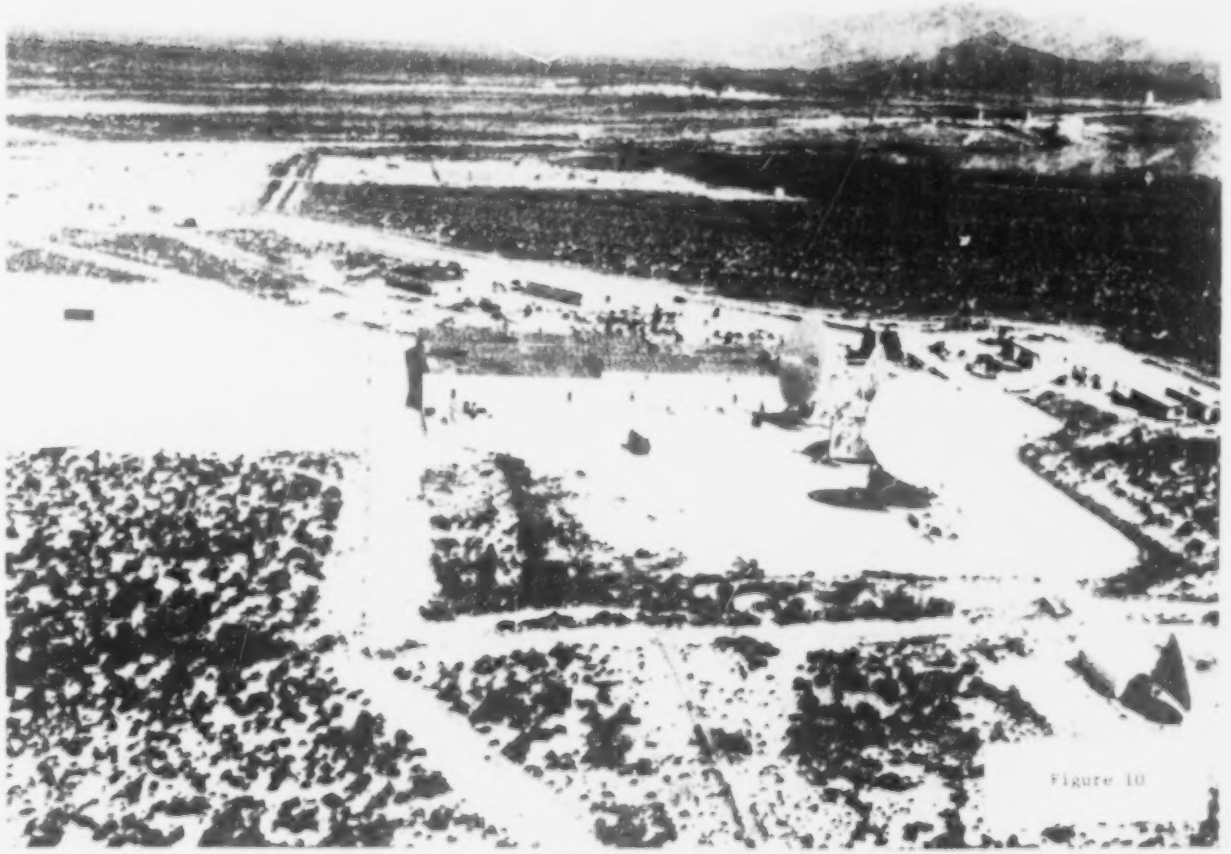


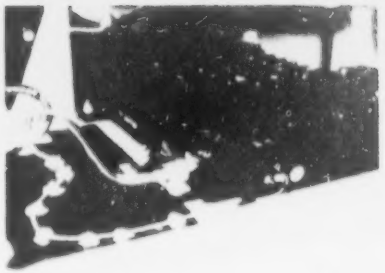
Figure 10

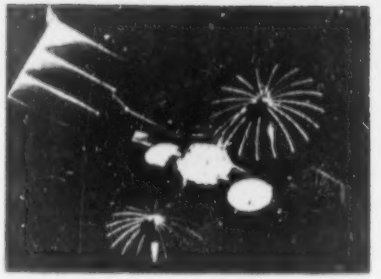
# TDRSS STATUS

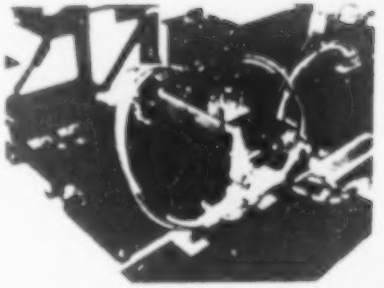
- TDRS-1 PREVIOUSLY HAS OR IS NOW PROVIDING MISSION SUPPORT TO:
  - SHUTTLE/SPACELAB (OPERATIONS SUSPENDED)
  - EARTH RADIATION BUDGET SATELLITE (ERBS)
  - SOLAR MESOSPHERIC EXPLORER (SME)
  - SOLAR MAXIMUM MISSION (SMM)
  - LANDSAT 4 AND 5
- TDRS-1 NOT FULLY FUNCTIONAL
- TDRS-2 WAS LOST IN JANUARY 1986



Figure 11







ANTENNA
CMD
TWTA S BAND AMPLIFIER (DUAL)
CMD
RECEIVE/*TRANSMIT DIPLEXER
CMD
ANTENNA
TLM
TELEMETRY
SGL ANTENNA
TELEMETRY
COMMAND
*S BAND COMMAND
S BAND TELEMETRY
SHUTTLE
WSGT
*MALFUNCTIONING AREAS/LOSS OF CAPABILITY

Figure 12

# TDRSS SPACECRAFT LAUNCH SCHEDULE

- TDRS-3 CURRENTLY SCHEDULED FOR LAUNCH FEBRUARY 1988
- TDRS-4 CURRENTLY SCHEDULED FOR LAUNCH SEPTEMBER 1988
- LAUNCH TDRS-5 AS SOON AS POSSIBLE TO REPLACE TDRS-1
  - — TDRS-1 LOST ONE REDUNDANT S-BAND COMMAND LINK
  - — K-BAND COMMAND LINK PREVIOUSLY LOST ON SAME ANTENNA
- TDRS-6 WILL BE STORED



Figure 13

# TDRSS REPLACEMENT PROGRAM

- NEEDED TO ENSURE CONTINUITY OF SERVICE IN EARLY 1990'S
- TO PROVIDE FOR ACQUISITION OF ADDITIONAL SPACECRAFT WITH INITIAL DELIVERY SCHEDULED IN 1991
- TWO-PHASE, SOLE SOURCE CONTRACT WITH TRW FOR REPLACEMENT SPACECRAFT WITH OPTION FOR A SECOND SPACECRAFT
  - — DESIGN OF REPLACEMENT SPACECRAFT IS FUNCTIONALLY IDENTICAL TO EXISTING TDRS DESIGN
- PHASE I TO DETERMINE DESIGN CHANGES NECESSARY FOR PARTS AND COMPONENTS
- PHASE II WILL CONSIST OF FULL SCALE DEVELOPMENT



Figure 14

# SPACE NETWORK

## FUNDING REQUIREMENTS

| | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|
| • SPACE NETWORK | $407.3 | $481.5 |

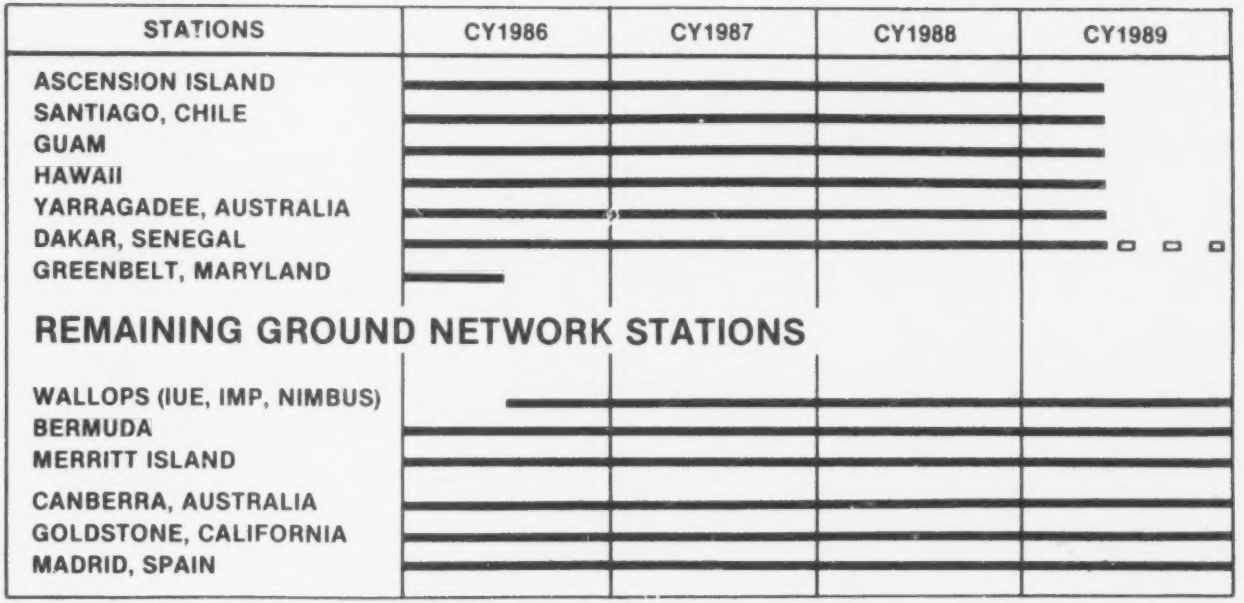


Figure 15

# NASA SPACE TRACKING AND DATA NETWORKS

Figure 16

# GROUND NETWORKS PHASE DOWN PLANS




ASSUMES 2ND TDRS LAUNCH EARLY 1988

▭ POTENTIAL EXTENSIONS

Figure 17

# DEEP SPACE NETWORK (DSN)
# 1987 ACTIVITIES

- SUPPORT FOR MAJOR IN FLIGHT DEEP SPACE PROJECTS
  - VOYAGER 1 & 2
  - PIONEERS 10 & 11
  - PIONEER VENUS ORBITER
  - ICE
- SUPPORT FOR LOW EARTH ORBITERS
  - NIMBUS-7
  - ISEE 1 & 2
  - DE-1
  - LANDSAT 4 & 5
- PREPARATION FOR VOYAGER NEPTUNE ENCOUNTER
  - EXPANSION OF 64-METER ANTENNAS TO 70-METERS (SPAIN AND CANBERRA)
  - INTERAGENCY ARRAYING
    - VERY LARGE ARRAY (VLA) NEW MEXICO
    - PARKES RADIO ASTRONOMY OBSERVATORY AUSTRALIA
    - USUDA SITE IN JAPAN - NON REAL TIME
- PREPARATION FOR FUTURE FLIGHT PROJECTS
  - GALILEO
  - ULYSSES
  - MAGELLAN
  - MARS OBSERVER



Figure 18

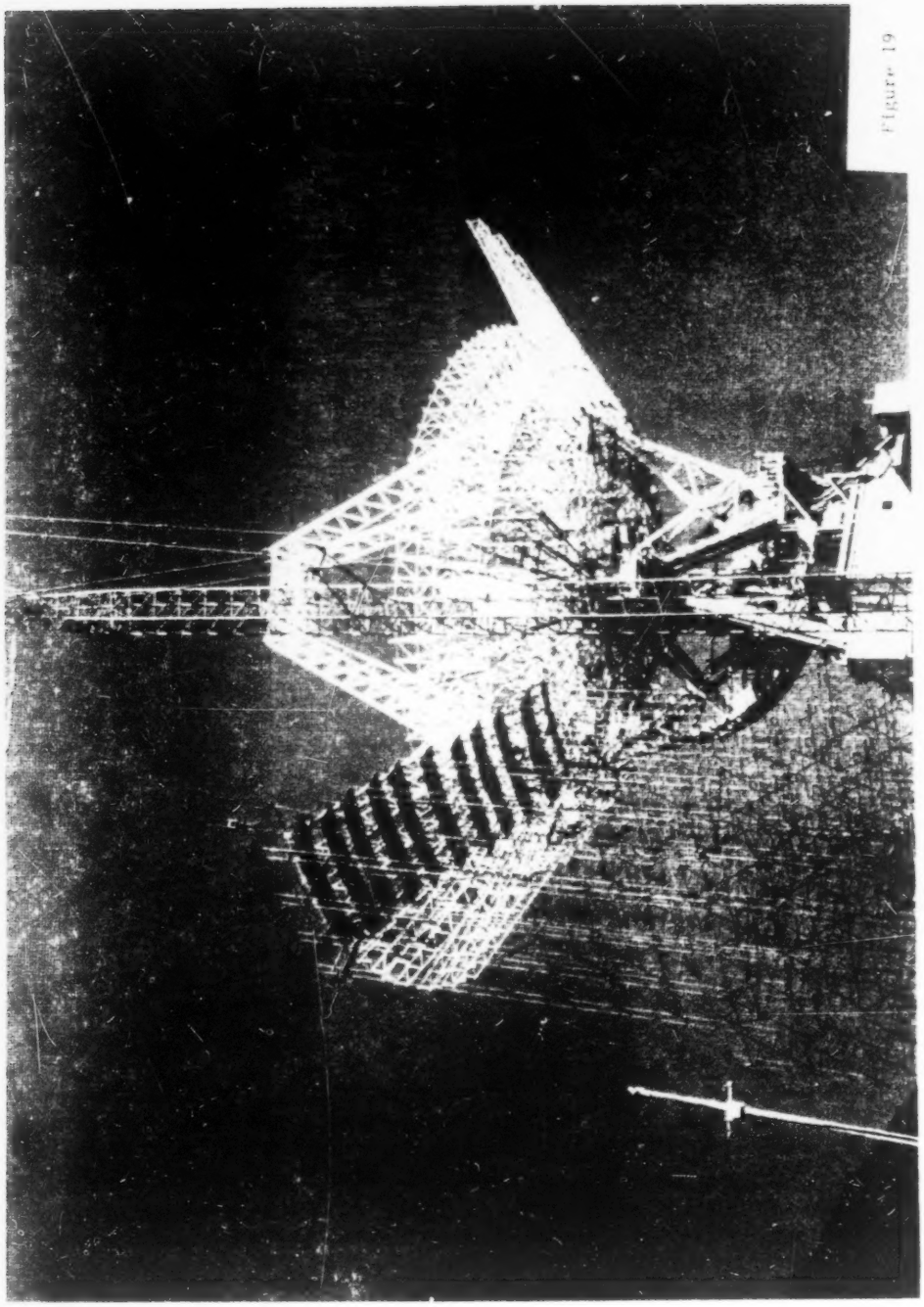
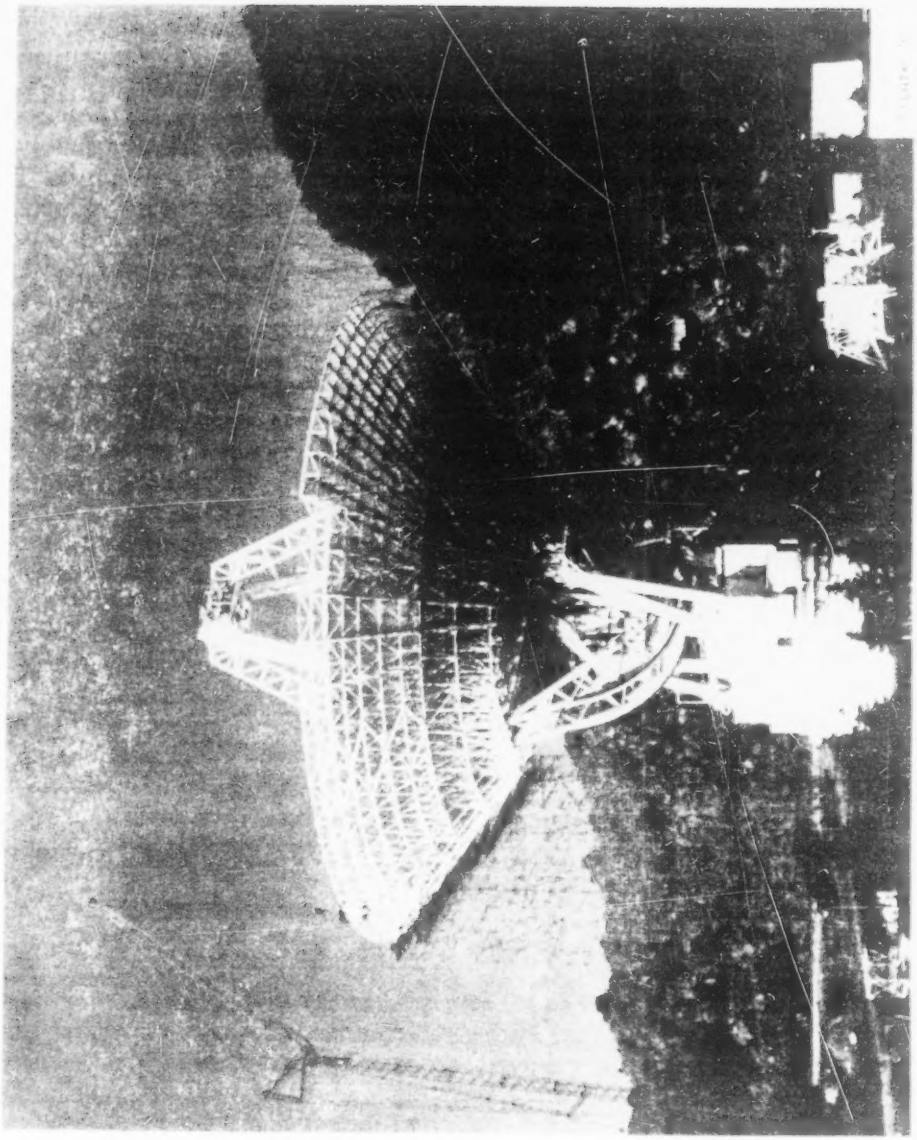


Figure 19



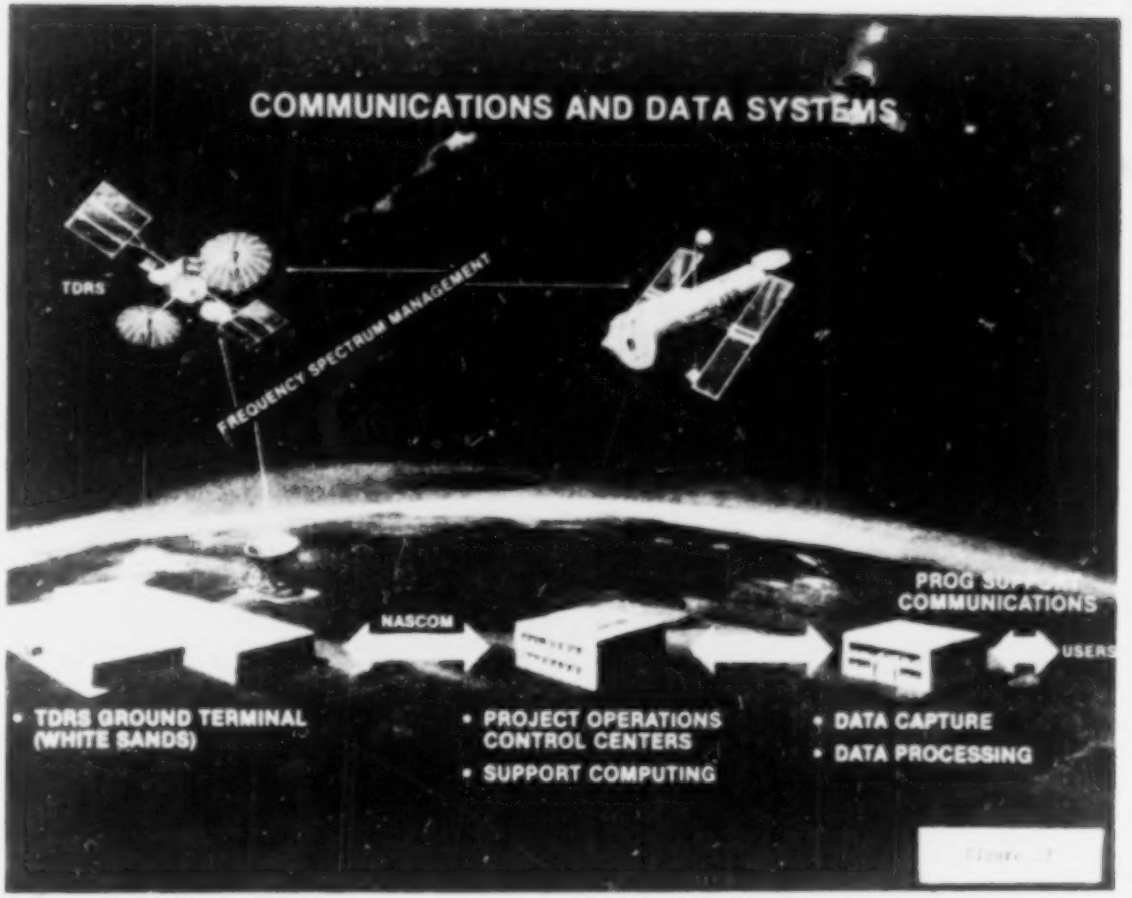
# GROUND NETWORKS

## FUNDING REQUIREMENTS

| | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|
| • GROUND NETWORKS | $250.1 | $257.1 |



Figure 21


COMMUNICATIONS AND DATA SYSTEMS
TDRS
FREQUENCY SPECTRUM MANAGEMENT
NASCOM
COMMUNICATIONS
USERS
• TDRS GROUND TERMINAL (WHITE SANDS)
• PROJECT OPERATIONS CONTROL CENTERS
• SUPPORT COMPUTING
• DATA CAPTURE
• DATA PROCESSING

# COMMUNICATIONS AND DATA SYSTEMS

## FUNDING REQUIREMENTS

| | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|
| • COMMUNICATIONS AND DATA SYSTEMS | $205.5 | $210.3 |



Figure 23

# SPACE STATION PLANNING

- PROVIDE DATA DISTRIBUTION COMMUNICATIONS FOR HIGH DATA RATE PAYLOADS
- DEVELOP DATA SYSTEM COMMUNICATION STANDARDS
- DEVELOP CUSTOMER DATA OPERATIONS SYSTEMS (CDOS)
- PROVIDE FOR SPACE NETWORK INTEROPERABILITY



Figure 24

# CUSTOMER DATA AND OPERATIONS SYSTEM (CDOS) PLANNING FOR THE SPACE STATION ERA

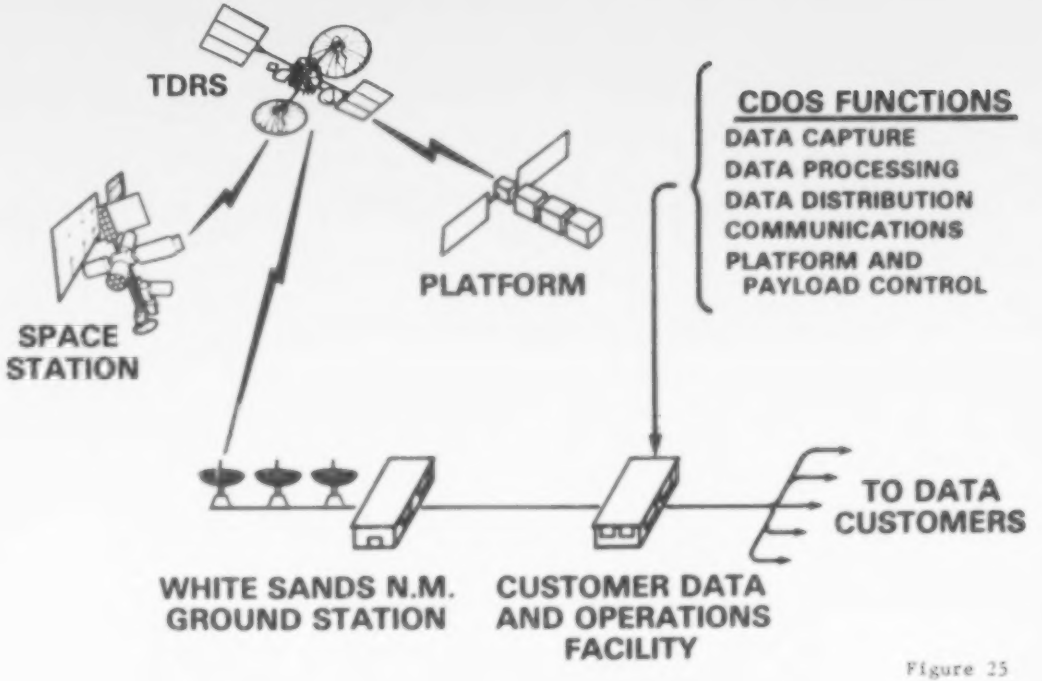



Figure 25

# SPACE NETWORK CONCEPT

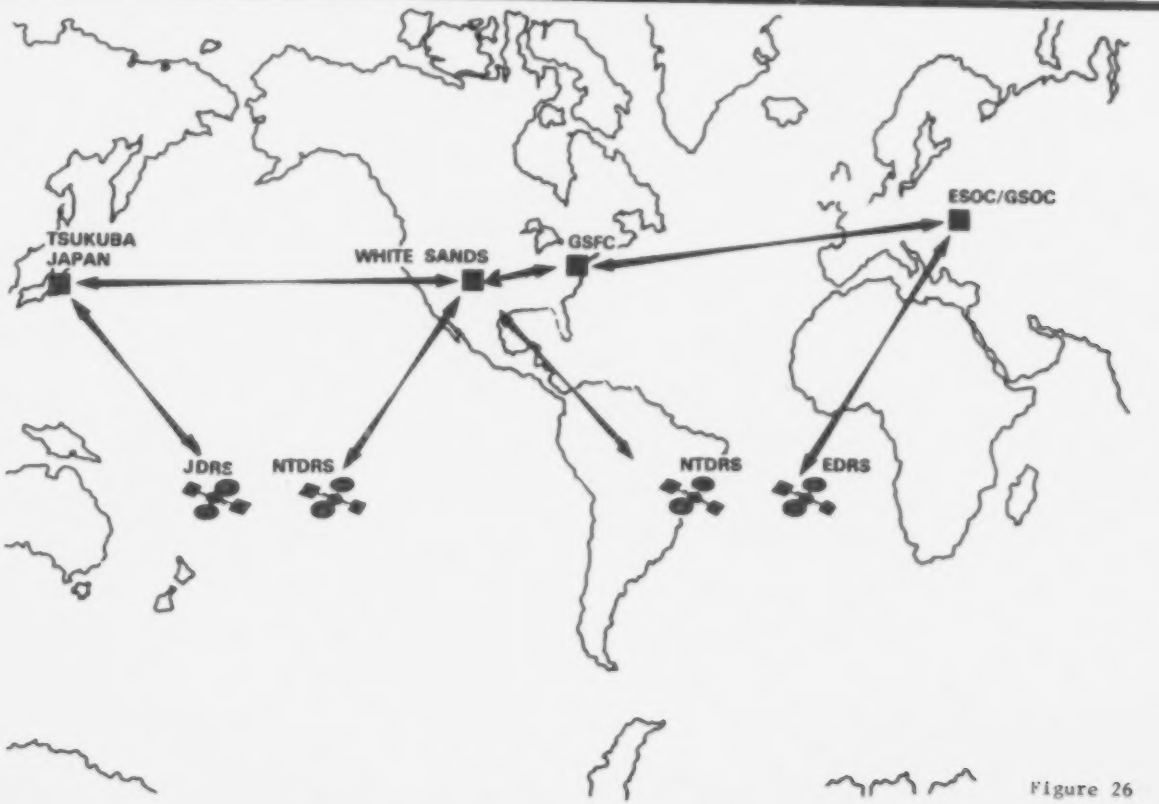



Figure 26

# SUMMARY

- $967M REQUESTED IN FY 1988

  - FOR CONTINUED OPERATION OF SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

  - REPAYMENT OF TDRSS DEVELOPMENT LOANS

  - TDRSS DEVELOPMENT INCLUDING REPLACEMENT SPACECRAFT

  - GROUND SYSTEMS IMPLEMENTATION TO ACCOMMODATE ONGOING AND UPCOMING MISSIONS AND TECHNOLOGY DEVELOPMENT

  - INCREASE FROM FY 1987 TO FY 1988
    - PROCUREMENT OF TDRS REPLACEMENT SPACECRAFT
    - CONTINUED DELAY OF TDRSS WITH TWO LAUNCHES FUNDED IN 1988
    - INFLATION



Figure 27

# SUMMARY (CONTINUED)

- MAJOR CHALLENGES
  - TWO SUCCESSFUL TDRS LAUNCHES
  - PROVIDE CAPABILITY FOR ADDITIONAL TDRS LAUNCH
  - SUPPORT HUBBLE SPACE TELESCOPE
  - INITIATING IMPLEMENTATION OF TDRS SECOND GROUND TERMINAL
  - MAINTAIN OPERATIONAL GROUND NETWORK
  - CONTINUE PREPARATION OF SPACE STATION MISSION SUPPORT
  - ESTABLISH CONSOLIDATED SPACE OPERATIONS PLAN



Figure 28

Mr. NELSON. Thank you, Mr. Aller. Mr. Hayes.

Mr. HAYES. Good, I'm glad the microphone is working. It was embarrassing day before yesterday when our subcommittee didn't have operable microphones. It made everything else in technology seem, at best, questionable.

I appreciate the appearance, and of course with my position on this committee unburdened by any of the restraints of experience, it allows me to perhaps make an inquiry of things that while more simplistic could in one way be more revealing.

On Friday night with the chairman as my host, I attended a reunion of Mercury astronauts. I want to tell you what that meant to me before asking the question. I remember standing in a schoolyard at F.M. Hamilton School in Lafayette, Louisiana and hearing the news that the Russians had put into space something that I had absolutely no understanding of but innately feared.

As a child I feared it because it represented that everything I had been taught about this country leading in technology had in an abrupt sound of a rocket's engine moved itself to another corner of the world.

As a high school sophomore seeing John Glenn make that flight restored to me the confidence that I had felt in government. And seeing the reunion was not so much nostalgic, but to me represented where we had gone to, and now where we wanted to go.

If this is one of the steps in the Mars mission, and if it indeed is one of the principal, as the President himself stated in his state of the union address, one of the principal symbols of this country returning to that prominence, then this congressman for one, without experience, without additional expertise, but with only that memory is a strong supporter.

Therefore, the questions that I'd like to know evolve around the shuttle, the platform, and ultimately the direction which we're going and hopefully toward Mars. What would be the role of your agency and your title in the newly created format which I probably don't completely understand? What will you do, for example, in relation to shuttle operations once we're again operational? What's the role that you have in that?

Mr. ALLER. Congressman Hayes, I would like to fully respond to that question. However, at this point in time the role of space operations has been in place approximately one month. What I've been asked to do——

Mr. HAYES. We're both newcomers then.

Mr. ALLER. Certainly in that vein we are, yes, sir. What I am doing is laying out exactly what will be the answer to your question in the Shuttle, in the Space Station, in the low earth orbit programs, in the planetary program. What will be the role of space operations, what are the elements of that that we will migrate into the office that I am presently the administrator of?

I cannot answer specifically for you the elements of shuttle operation that we will eventually manage. However, I look at operations generally as providing the capability and capacity to conduct operations in space. So the elements that NASA has, the resources that NASA has for capacity and capability will come under the management of space operations when we establish that function.

One of the things we don't want to do at this point in time is interrupt the ongoing shuttle recovery. It's very important that Admiral Truly and his staff and his program and his centers focus on the recovery of the shuttle. And the operation aspect of that comes under Admiral Truly and will remain there until we have established a more gradual evolution of some of those operational functions into space operations.

Mr. HAYES. Well, let me from your response then draw a parallel to the $8 billion initial suggested figure. I come from a background of building buildings. It's finite enough to be able to come within 5 and 10 percent on the worst day. But from what you've just said, in taking over that office, isn't it fair to say that an $8 billion initial estimate is also based upon not a finite technology or experience, but simply a guess of what technology has to be developed along the pathway? And consequently in the same position in which you find yourself, it's not really an increase but a figure adjusted through additional information?

Mr. ALLER. Congressman Hayes, I could give you my view of that comment. However, if I may, I would like to defer a more knowledgeable answer to Mr. Stofan who will be a witness in a few minutes on the Space Station program and the costs associated with that program. I'm really not that familiar at this point in time with those costs.

Mr. HAYES. All right, I'll pass until that time. And in light of the fact that we're probably fixing to have to go vote, pass on to the next inquiries to be made.

Mr. NELSON. How many associate administrators are there?

Mr. ALLER. A bunch. [Laughter.]

I can tell you the ones that are associated with programs and, I think, represent the bulk of the activities in the agency. Mr. Stofan, of course, is the Space Station. I have now space operations. Admiral Truly is the national space transportation system, basically the shuttle and ELVs. Dr. Edelson is science and application. Dr. Colladay is aeronautics and technology.

Those are the major programs that develop the vehicles and the hardware and the operations for NASA. There are other associate administrators and I'd rather not try to name them all, but I've just been handed my chart and I can count them. There are——

Mr. NELSON. So you've listed——

Mr. ALLER [continuing]. Ten.

Mr. NELSON. Okay, you've got 10. I want to make a suggestion to you. You have just heard a member of Congress pour out his heart about his dreams for the future of this country. I think that you ought to be having rump sessions as the lieutenants with Dr. Fletcher, getting in a room and start dreaming dreams. So that all of you are looking beyond your areas of specific responsibility, into coming up with a mosaic, a composite of where this nation goes so that when a congressman pours out his heart like he did that you can start dreaming dreams with him from the witness table.

That would be a recommendation, and I will suggest that directly to Dr. Fletcher.

Mr. ALLER. I think that's a good suggestion, Mr. Chairman. I should say that we do have sessions, as a matter of fact, Friday and Saturday of this week. We have a session in town here where all

the associate administrators, as well as the center directors meet with Dr. Fletcher and Mr. Myers for two days and talk about our long range planning and strategic planning for the agency.

This is the most recent of several of these type meetings. They're very important to us, we certainly agree with that. And I agree with the comment and we're proceeding along those paths.

Mr. NELSON. Any other members for questions or comments? Mr. Walker, and then we'll get Mr. Nagle.

Mr. WALKER. Mr. Chairman, my comment is that one of the problems is that it's not just that NASA doesn't dream but that we in Congress and government don't dream either. And the problem is that we haven't outlined a sense of dreams to drive the NASA programs, too. It's probably more our fault than theirs, so I think we need to be aware of it.

Out of the 960—to get back to money—out of the $967 million that you're requesting, how much of that is nonrecurring costs that we will not have to pick up again in 1989?

Mr. ALLER. I would have to put that number together.

Mr. WALKER. Is it a fairly big number or fairly small number?

Mr. ALLER. I believe you will find that our budget over the years for operating and implementing, other than the times we have special problems like we had with the TDRS spacecraft is generally an ongoing budget as you've seen in the networks area and in the communications and data area. It's basically operating, and maintaining an operating capability over the years.

In TDRSS we are implementing a major system, and that's where our major cost growths have occurred over the most recent times.

Mr. WALKER. Okay, I'm not going to quarrel with you about '88, but when I look at your major challenges ahead, it appears to me, based upon the figures you gave me a few minutes ago, you're going to be in next year then for a fairly walloping big increase in '89, because you're going to need $90 million or so for space station development.

Mr. ALLER. No, sir. No, we don't need that much in 1989. I believe our estimate for Space Station is more in the neighborhood of $10 to $20 million, as I recall.

Mr. WALKER. Well, at some point then you're really going to have a walloping big increase to get that $360 million we talked about a few minutes ago.

Mr. ALLER. Yes, sir, it begins to grow in 1990. We indicated from '90 to '93 are the major growth.

Mr. WALKER. Okay. So at that point—but I'm also looking at the support for the Hubble Space Telescope. What's that figure likely to be in 1989?

Mr. ALLER. The figure for the space telescope will be an operating number for the facilities that we have put in. I can provide it for the record, but I'd like to scope it and say that the operating cost for the Space Telescope will be within the $15 million range for us.

[Material referred to follows:]

The unique recurring costs for the Office of Space Operations (OSO) support for the Space Telescope in FY 1989 will be approximately $6 million. Space Telescope will also utilize multimission facilities operated by OSO; the costs of operating these

facilities are included in OSO's baseline budget and are not separately identifiable by project supported. The $6 million cost includes operation of the Space Telescope Control Center for the mission scheduling, command and control of the spacecraft and operation of the HST Data Capture Facility for the capture, quality assessment, accounting, processing and transfer of data to the Space Telescope Science Institute.

For completeness, the Office of Space Science and Applications (OSSA) recurring operations costs for the Hubble Space Telescope in FY 1989 are $83.9 million. This includes the ground systems, the Space Telescope Science Institute, and support for research scientists. These costs are based on a November 1988 launch data.

Mr. WALKER. Okay. So that those are add-on costs though. Those two costs alone are add-ons of about $40 million for next year.

Mr. ALLER. No, sir. We are presently maintaining roughly the level of operating capacity for Space Telescope as we're running tests with the Space Telescope at Sunnyvale today for those facilities, as we will need when we operate those facilities roughly.

Mr. WALKER. So in other words, that will not be an increased cost.

Mr. ALLER. No, sir.

Mr. WALKER. The cost for operation should be the same as the cost for maintenance right now.

Mr. ALLER. It should not be an increased cost, that's correst.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. Well, Mr. Chairman, let me say that I would like to share the memory of Congressman Hayes when the Russians put that ship in space, but unfortunately at the time I was too young to remember it. [Laughter.]

Mr. NELSON. Dream on.

Mr. HAYES. Or too ignorant to have noticed. [Laughter.]

Mr. NAGLE. Dreams are what this is about. Could I see the chart—did you have a chart on the time line on the three satellites? Did I see that? I think the first one went up with the shuttle in February of '88.

Mr. ALLER. Yes, you did.

Mr. NAGLE. Could we get that back up again? While you're doing that, I would only note that you can see what happens to an honest man who tells the truth in this committee, he's belittled by his colleagues.

Mr. ALLER. Figure 13, please. Is this the chart you're referring to, sir?

Mr. NAGLE. Yes, thank you. Now that goes up in February '88, we put number 3 up. And then in '88, the fall, we put number 4 up. And 5 is—when do we anticipate putting 5 up? I know it's as soon as possible, but——

Mr. ALLER. Our plans are to attempt to launch the third one by about the fall of 1989.

Mr. NAGLE. Now these are designed to serve a multitude of purposes in addition to the Space Station; is that correct?

Mr. ALLER. That's correct.

Mr. NAGLE. And are they capable of being launched by a disposable vehicle?

Mr. ALLER. Expendable vehicles, yes, sir. The problem we have on launching on an expendable vehicle is the vehicles available today can only place 4,000 pounds into geosynchronous orbit. This vehicle weighs 5,000 pounds. Now we are looking at downloading

our fuel, hydrazine fuel that maintains the attitude on orbit, by the necessary weight to allow us to be launched on an available spacecraft.

When the Titan IV is available, which is the newer version of Titan that the Air Force is developing, they can put the entire payload weight into orbit.

We have some other spacecraft modifications. You don't just take a spacecraft out of the shuttle and put it on the launch vehicle. We have to look at the loads associated with those expendables, and we have some minor modifications to accommodate on an ELV. But we are fully capable of launching on an ELV when one is available.

Mr. NAGLE. Now one second question. The Titan IV will be available when?

Mr. ALLER. The Titan IV is planned to be available to the Air Force in the 1988–1989 timeframe, as I understand it. When one will be available to NASA is not known to me.

Mr. NELSON. It's possible in 1991, but more likely in 1992.

Mr. ALLER. However, a 34D, which is the existing configuration that the Air Force is trying to get back into an operational condition—it's their next large flight—is what we could use to launch 4,000 pounds into geosynchronous orbit. And that is a possibility of getting our third spacecraft into orbit.

Mr. NAGLE. Is there a relative cost difference between using the expendable or the disposable launch vehicle and the shuttle itself? Is there a major difference in cost?

Mr. ALLER. There's a cost consideration in that we would have to fund whoever we buy the expendable launch vehicle from for the services of that launch vehicle that do not exist in my budget, or to my knowledge, in NASA's budget.

Mr. NAGLE. I guess what I'm driving to is, are there contingency plans within the agency, or is the agency making contingency plans in the event that the shuttle is delayed for an expendable launch for these satellites?

Mr. ALLER. Yes, sir, the contingency plan I have is to—and I have requested this—the launch capability in the agency is provided by Admiral Truly with the shuttle and through expendable launch vehicles. And I have requested the availability of a 34D in that situation, that if the shuttle is not available in the reasonable timeframe of February of 1988 or a few months thereafter, that a 34D be available to launch the TDRS–3 spacecraft into orbit. That's our contingency plan at this point in time.

If we do not need that 34D, we will launch the third spacecraft on a 34D, if one is available. That is a scarce resource.

Mr. NAGLE. I understand that. I think you can—at least my concern, I think is that if the shuttle is delayed and we're putting all of our eggs on the shuttle going off on time, then a whole host of other projects and functions would be held up if we don't have contingency plans.

Mr. ALLER. Yes, sir, that's very true. And we're supporting users in orbit today with the existing spacecraft. However, there is a factor that must be considered, and that is that the major users, the high data rate users, the space telescopes, the shuttles, the space labs, those types of programs are also dependent upon shuttle launches.

Mr. NAGLE. I understand that. Thank you. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Nagle, one of the recommendations that Chairman Roe and I are going to have to this subcommittee is the possibility within the fiscal year '88 budget of funding a Titan III so that they can get that TDRS–5 up.

You probably heard my comments yesterday when Mr. Myers was here, the harsh reality is that since we've been down so long and the payloads are stacking up on us, backing up on us, that between now and 1995, including the replacement orbiter, you're going to need about 125 expendable launch vehicles to get all of the payloads that we have to get up, over and above what the shuttle can fly. And yet NASA comes to us, because of OMB directing them to, and not come to any request in this fiscal year '88 budget for any ELVs to start the process.

Now two of them that we are going to recommend to this committee to put in at this point, as much information as we have is, one, to get that TDRS–5 up. And another one is to keep that Mars observer on for 1990 instead of slipping it to '92 as NASA has requested.

Mr. NAGLE. Well, all I can say, Mr. Chairman, is that I think that shows great insight by you and Chairman Roe and I'm supportive of your efforts in that regard.

Mr. NELSON. Any other questions from the committee? Mr. Buechner then Mrs. Morella.

Mr. BUECHNER. I'm aware of the fact, of course, we've got Japanese and European communications satellites currently up there. Is there any way that we can devise an interoperational system that might mean that we don't have to do as much with TDRS? Is there a way we can guarantee our own sovereignty, but take a recognition that they are there and if we can implement some usage, maybe it's the cheapest and most functional way to do it. I'd appreciate any comments you'd have on that.

Mr. ALLER. Let me try to clarify communications satellites generally if I might and the TDRS.

Mr. BUECHNER. I meant TDRS, I'm sorry. I said communications, but I think they have data transmission satellites, do they not?

Mr. ALLER. They are planning them, sir, in the mid-1990s. What I was referring to previously in my statement is, of the partners that are involved in Space Station we are the only ones that have a system approved, operating, and will have it available over the next several years. Both Japan and Europe plan to put them up, and we plan to work with them so that we can operate through their systems when they are available.

I must emphasize, neither of these programs to my knowledge are approved, either in ESA or in NASDA in Japan. But they're planning to provide their satellites along with some major ambitions they have relative to space station and other programs. And we would plan to utilize that capability when it exists.

Mr. BUECHNER. What, looking forward to the Deep Space Network, have you got any projections as to what budgetary outlays we're looking at in order to provide the encounter of Voyager II with Neptune and the Galileo mission in 1989?

Mr. ALLER. I believe the major expenditures on the Deep Space Network to meet the encounter in '89, was a very exciting mission, are basically underway. In the expansion of the capability we have in the three Deep Space Network sites, we're expanding those large antennas and we're proceeding with what we call arraying with other antenna systems.

For instance in Soccoro, New Mexico the National Science Foundation has 27 25-meter antennas that are arrayed for science astronomy. We are tying that array into our own system at Goldstone, that basically doubles our capability to receive the very weak signals back from Neptune in 1989. Those activities have been funded over the past several years, and our basic operation in the future will be this year and next year will be complete that implementation and to get into that operation in August of 1989.

Mr. BUECHNER. One last comment. And I know Congressman Hayes very eloquently spoke of the dreams that he had and continues to have, and I think it's shared by a lot of us. But as you know, we are faced with reality. That we've been sent up here to not just dream. And that is, we do have a lot of fiscal restraints.

And I hope that as you and the other members of NASA come before us that they will make sure that they prioritize, since it is not an unlimited amount of funds that we have, so that we can, even by enhancing our dreams with such things as the ELVs, that we can keep it in perspective that there are a number of dreams to be answered and a number of realities to be met.

Mr. HAYES. I believe the gentleman from Texas, Mr. Chapman is next.

Mr. CHAPMAN. Let me ask just a couple of questions quickly. But for the Challenger accident, how many shuttle launches would have occurred since last January 28th of '86 up until now? Do you know approximately or precisely?

Mr. ALLER. In 1986 we had 12 launches scheduled. I believe that's the number. I don't see anyone nodding yes or no, but roughly 12 launches.

Mr. CHAPMAN. Since the program has been closed down, and assuming that those launches would require a substantial amount of resources and money in NASA, can you tell me if—did we save, or has there been any cost savings as a result of not flying? And did NASA spend any less money than was budgeted as a result of not flying last year?

Mr. ALLER. I can only speak to the area of tracking and data, and I will do that, Mr. Chapman. There was a much broader savings in some of the areas directly associated with the shuttle program. But in tracking and data we, of course, have continued to operate. We were supporting shuttle, but we're supporting roughly about 20 satellites a year, and we've continued to do that.

However, we did have considerable savings in the communications network that was in place specifically for the shuttle program. We have stood that network down during the downtime of shuttle. We've reduced the capability, the data processing capability at the Goddard Space Flight Center associated with flying shuttle missions until the shuttle program comes back on-line.

So those savings were incurred by tracking and data. There were other savings associated with the program involved in the other programs, in the shuttle program specifically.

Mr. CHAPMAN. Are you aware of whether or not any—I assume no—was there any money turned—what did we do with the money we saved? Or did you spend it?

Mr. ALLER. That money was taken into account in the budgeting cycle last year, sir; those reductions.

Mr. CHAPMAN. Thank you.

Mr. NELSON. Mrs. Morella.

Mrs. MORELLA. Mr. Aller, I heard this morning on the radio that the settlement had been made with Morton Thiokol with regard to the Challenger. I don't know whether that's going to end up being a loss for you, too, as the ramifications are concerned and you probably can't answer that. But I was curious about the fact that that is the only company that currently is in the business of rocket boosters? Is that correct?

Mr. ALLER. No, Mrs. Morella, they're not the only company in the business of rocket boosters. They are the only producer at the present time for the shuttle solid rockets.

Mrs. MORELLA. Doesn't that say——

Mr. ALLER. For the unique rocket that is associated with the shuttle program.

Mrs. MORELLA. Right, but doesn't that say something about something that's gone awry in our free enterprise system where evidently we don't have the climate or the environment to encourage that kind of competition? Do you have a comment on that at all? It just surprised me to learn——

Mr. ALLER. Well, I will comment in that, generally speaking there—I think Congressman Buechner mentioned the priorities and the capability and the constraints we all must operate under. And the tendency of a program manager like myself is to provide all kinds of contingencies and capabilities that we can think of to assure the program is available and on-line. And then we have to live within the capability of the overall government's constraints and their priorities to operate that program. Now I'm not the one to deal specifically with the solid rocket motor issue.

Mr. NELSON. Admiral Truly is coming on March 5th in front of the committee, and as the head of space flight operations, and also as a former commander of a crew, he will give you a detailed answer to that question.

Mrs. MORELLA. Very good. A further question. In terms of what our plans are, you've presented that quite well. How do we compare with the Russians in terms of our satellites and the launchings? I mean, I know supposedly they're ahead of us. Can you give us a synopsis of where we stand in terms of the immediate plans that you've presented to us and where they are?

Mr. ALLER. Mrs. Morella, I can give you my view of what I understand of the Soviet program. I was the deputy director of the Apollo-Soyuz program approximately 10 years ago. You know, there are measures that can be made relative to our activities and theirs.

If you look at number of launches, it would be frightening. Their launches, as I recall, number in the 90s. In the past year ours num-

bered 10 to 12. There's something that's being put into orbit with every one of those launches.

As far as the capability, however, that I am representing in this program, the tracking and data technology, it is my opinion that there is no country in the world that compares with our capacity in tracking and data. And we experience that, with the support that we're asked to provide particularly in the Deep Space Network for the many probes that are conducted. Not only by the Soviets, but as well as the Europeans.

In the past year for the Halley comet mission, for instance, although we were greatly criticized for not having our own individual spacecraft associated with that program, we did support six spacecraft on the Halley comet mission with the Deep Space Network. We supported both of the Vega spacecraft, part of the Pathfinder program from the Soviet Union. We supported the Giotto program from Europe. We supported two Japanese satellites, a Planet A and one other. And we obtained some data from Pioneer Venus, our own spacecraft, from the Halley mission.

I think from a technology standpoint—and I don't have a great deal of insight into the Soviet technology—but from my experience and the capacity that we have for tracking and data and the fact that they have asked for our support on various occasions, I believe we have been as capable in those areas as exists.

As far as the TDRS system, I do not have direct information relative to their capability to conduct that kind of a program. That is a new operating philosophy, a new operating technique for conducting operations where we move the ground station into orbit. And it presents a lot of operating problems, a lot of logistics problems, as well as the problems associated with getting the satellites up there in the first place. But that system has operated well and it's provided significant support to us.

I think in the area that I represent, which has also a lot of data processing in it, that our capacity in data processing is second to none.

Mrs.. MORELLA. Can you see us working together collaboratively with other countries and gaining the knowledge on both sides, and not reinventing everything?

Mr. ALLER. We have many cooperative programs, Mrs. Morella, already underway, principally in the scientific area where we exchange the scientific information. We fly instruments on some of the European satellites. They certainly fly some on ours in the spacelab program. There are many cooperative programs between the Japanese and the Europeans and us. The area I represent supports them all. But from the science standpoint, there are considerable exchanges of cooperative data, cooperative information.

The only program that we have operated on in space with the Soviets is the Apollo-Soyuz program from an active standpoint.

Mrs.. MORELLA. Probably an area where we could do more. All right, thank you.

Mr. NELSON. Thank you, Mr. Aller. Would you supply for the record, the TDRS system of six satellites was supposed to take us through the year 2000. And you have stated here today that it will take us through the year 1995. Supply that for the record.

[The material referred to follows:]

The original six spacecraft were planned to operate in a four satellite constellation to provide both commercial and NASA service for a ten year period. No extended NASA service was provided in the contract, and at the end of the service period the commercial segment would have title to one of the remaining spacecraft.

In 1982 when NASA acquired dedicated service and the constellation reduced to three spacecraft, it was anticipated that dropping commercial service requirements would increase the life of the System beyond the ten years of the service period to the mid-1990s.

Prior to the Challenger accident, an improved version of the TDRS spacecraft was planned for the 1994–1995 time frame to provide system continuity. In the post-accident reevaluation, a replacement spacecraft to be available in 1991 was added to the program to insure network viability into the mid-1990s.

An advanced version has been replanned, subsequent to the accident and the addition of the replacement spacecraft, for the 1996–1997 period. NASA has initiated studies with several contractors for this advanced system that will provide the continuing capability required for an operational Space Network.

Mr. ALLER. I'll supply it for the record.

Mr. NELSON. Okay, thank you. Chris, I didn't see you down there.

Mr. PERKINS. I don't know exactly—and I apologize for being late—I don't know exactly where to start in this. But just in terms of the variable g capability that would be necessary to going towards, let's say a Mars expedition. What present type of planning is NASA doing in this regard?

Mr. NELSON. I'm going to ask you to defer that. Let's get Mr. Stofan up on the talking of the space station, and then we can expand our imaginations from there on that question. And I think that is an excellent question and let's find out what Mr. Stofan's going to do about simulated gravity on a space station and/or future vehicles that would go to Mars, which is exactly what you're talking about.

Mr. PERKINS. You don't want me to talk about the Mars observer then, too?

Mr. NELSON. Let's—we've got a specific hearing coming up on the Mars observer with Dr. Edelson on March 3.

But, Mr. Perkins, go ahead, you frame the issue.

Mr. PERKINS. Essentially as I see it—of course, I think one of the things that we need to be working and concerned about in terms of this committee is policy or lack thereof. It does not appear to me that we have, in talking with a number of people over the last several weeks, any sort of explicit policy that leads towards a goal in space.

Dr. Sagan and Dr. Murray, of course, have indicated that we need an intermediate type of goal such as a Mars expedition. We went to the moon, I guess, in eight years after the 1961 call to Apollo. And I asked Dr. Murray last week, he indicated to me that we had the capability of doing a Mars expedition within a relatively short period of time. I think I heard Dr. Fletcher comment on T.V. on CNN that we were talking maybe 15 years in terms of a Mars expedition if we were in fact so inclined.

I'm supposedly generally trying to frame the question of where are we going and once we have some sort of goal, how are we working towards that goal with the important programs such as variable g, which everyone indicates is necessary, and some of the—a variety of other type of programs that are necessary to fulfill that goal? And that's basically where I'm coming from on this. So I'll frame it. I don't know——

Mr. NELSON. Okay, let's just hold it right there and we will get to that. Mr. Aller, thank you very much.

Mr. ALLER. Could I take a moment of the time? I know your interest in the past of recognizing many people that have worked in NASA over the years and get very little recognition. I've asked to come with me today a gentleman that will be retiring this year that has been responsible for the tracking and data budgets for the past 22 years. He's a budget officer, and has been very valuable to me and my three predecessors in this job.

And I would just like to ask Ron Theisen—would you raise your arm, Ron? Ron has worked vigorously——

[Applause.]

Mr. NELSON. Ron, you obviously have been successful in your work because you have a system that although we never thought could get into operation, you got it up there. And as crippled as it may be, it still works. And some of the crews say it works too good, because you can never get away from the radio once you're up there. Whenever you get within that sphere of TDRS you know you've got to be talking. So you obviously are doing very successfully and we commend you and we congratulate on a distinguished career.

Mr. ALLER. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Aller. Mr. Stofan.

Okay, and I invite all the rest of you standing by the door to come in and fill in the empty seats.

All right, Mr. Stofan, you've never known us to be very orthodox around here. To the contrary, you've known us to be rather unorthodox. So let's start off with two members of Congress who wanted to stretch their imaginations, Mr. Perkins and Mr. Hayes. All right, pose your question, Mr. Perkins.

Mr. PERKINS. Let's talk about where we're going. Let's talk about—what are we talking about as an intermediate range goal with NASA presently? I know Dr. Sally Ride is probably working on a report right now that we've been promised on March 15 that hopefully will get on that timeframe that will give us some indication of what NASA's plans are for the future.

But, you know, I've read information. I think the National Commission on Space's report indicate that from the available data that we had on some of the Soviets and what limited data we did have, there was severe problems, for example, after they've been up for a long period of time and when they came back to the planet Earth and they had problems doing basic sorts of functions. And that we needed some sort of research.

I guess Mars has a different gravity, .34 of what the planet Earth is. So obviously they were talking about some ideas of starting out at 1 g, going there over a period of time maybe, kind of over a period of time going to .34 g.

What is being done, for example, with the variable g right now, and should that be incorporated into the present day space station, as opposed to some of the other things that we're looking at right now?

Mr. STOFAN. Congressman, I will try to answer the question. But again, I would suggest that you address that on March 3rd to Dr. Edelson who has the life sciences organization reports to him. And

so, the science field belongs to him. The station, construction of the station itself is in my responsibility.

Mr. PERKINS. Okay. It relates to the space station very definitely.

Mr. STOFAN. Yes, it does.

Mr. PERKINS. Some people suggest that we should be involved in the space station in this area right now.

Mr. STOFAN. Yes, I met with the medical advisory board that's chaired by Arnie Nicogossian who's the head of the life sciences, division director there, his people yesterday and we discussed the long range program with them that they have laid out to address the exact issues that you bring up.

The input from the medical advisory boards to date have been that if we were to go to Mars now, we should go in zero g, we should not provide a variable g. They have though, laid out a long range program that starts with the Space Station as being a necessary and essential element of the long range life sciences program, extends man's duration in space. That the Space Station is the key element to get that data that will allow and enable us then to go on.

And it starts out with a zero gravity, a base of gathering the scientific data which we do not have from the Russians, that is correct. And slowly building up that database to allow a longer and longer period of man in space. Also conducting experiments with centrifuges on board the Station. And maybe eventually, if the data indicates, to have some type of artificial gravity device there for man himself.

But they put that down as a much, much lower priority. And the reasons for that—I'm not an M.D.—so I think you should ask Dr. Edelson's people when they're here. And they could provide the background. But the bottom line, that's what they tell us. So they say the Space Station we're building is exactly what they need to extend man's duration in space.

Mr. PERKINS. I'm interested in that because I've heard conflicting opinions from other people that indicated that this was extremely important in the development and trying to get towards planets. We don't know how long we're going to be trying to get there and back, two to three years some people say for a single mission on a Mars shot.

Do I ask them about the Mars observer, or should I just wait?

Mr. NELSON. Let's wait because we're——

Mr. PERKINS. How about deep space probes?

Mr. NELSON. Let's wait on that for Dr. Edelson, too, and he can give it precisely. Chris, let me interrelate now with Mrs.. Morella.

Dr. Stofan, what you've got is a bunch of hard-charging new members on this committee, and they want to know everything about everything. Now unfortunately, you have to be—you happen to be in the witness chair. All right, now Mrs. Morella was interested about the Soviet program. All right, now you're uniquely qualified, having just said what you said to Mr. Perkins, why don't you tell her some of your commentary about what the Soviets have already done with their two space stations, and what capability they have as we're looking forward to the future. Then we'll get to Mr. Hayes.

Mr. STOFAN. Okay, then after that, I think it might be worthwhile to walk through at least a few of the viewgraphs because that scopes what it is that I'm responsible for and what I feel a little more comfortable talking about.

Mr. NELSON. Is it true that every NASA witness has to have viewgraphs? [Laughter.]

Mr. STOFAN. Some people need their hands to talk, I have to have a viewgraph.

Mr. NELSON. It seems like that everybody in aerospace has to do that. Anyway, go ahead.

Mr. STOFAN. That's true.

Mr. WALKER. There may be a major budget saving in cutting out viewgraphs at NASA.

Mr. STOFAN. If you took viewgraphs away from NASA headquarters it would shut down.

Mr. NELSON. It might shorten the testimony by 75 percent, too. [Laughter.]

Mr. STOFAN. Although compared to sitting there and reading and mumbling over a bunch of words that you have, I think the viewgraphs can express maybe some other points we can't make just verbally.

But getting to the Russian space program itself, to answer that question for you before I go on, is yes, indeed, they do have a very, very ambitious manned space program. They've had man-tended operations in space for a period of time. They now have what we consider to be permanent manned presence in space with the launch of the MIR, I think, on February 6th, if I remember rightly.

They plan to leave the people up, our understanding is—again, the data that we get is only an understanding—these people up 10 months. They are extending the period of man in space on a regular methodical basis with, it appears from what they say, they are intending to have a manned Mars mission.

Now the MIR Space Station is going to be expanded by adding modules one at a time with flights up each year. Now they have one up there. With another five flights they would get up to about 13,000 cubic feet of space. And that would be only five flights. And again, they could double that very easily, and by the mid-1990s have two Space Station complexes up with about 12 modules.

We know that the next module, from what we read in the journals is going to be an astrophysics module to conduct astrophysics research. And that has very, very heavy participation from the western nations in that module. We know they are going out and talking with other nations and encouraging them to join in with the Russian MIR program to provide science, instruments and astronauts to operate with their station. So they have permanent manned presence.

If we proceed with this program, it will be the mid-1990s before we do. And at that time they will have a very large, capable, viable scientific complex in orbit.

Mrs.. MORELLA. Mr. Chairman, may I ask, wouldn't it help us to work, to collaborate in some way with them in that regard? I mean, it's like we are definite competition. I recognize the competition we have with them in other areas, but would this not be one area where we could satisfactorily work together?

Mr. STOFAN. I don't know. Over the past 15 or so years of my experience in NASA—and again, several years ago I was in the space science program and we did have programs with the Russians. And it's been very cyclic over the last 15 years of starting to set up collaborations and working with them in the life sciences program, which we did at one time, working with them in the planetary program at one time. And then things come along like Afghanistan and the relationships break off for a period of years.

So that is something—what happens in the future, I have no idea. I think it has to do with things that are global in nature, and surely above my pay rank.

Mr. NELSON. The answer to your question from a policy level that is not necessarily above his pay rank is yes. The potential is there. It's how do we accomplish that by still protecting ourselves from the national defense standard, protecting ourselves from the transfer of technology.

And the model that we have, that was extraordinarily successful was Apollo-Soyuz, when an American spacecraft and a Soviet spacecraft rendezvoused and docked and exchanged crews in 1975. And out of that we protected the transfer of technology, but we benefited—we, the United States—in that we were able to peer into the Soviet system that otherwise had been closed. That because of the interchanges of the engineers, the technicians and the crews, that we were able to understand something about the operation of their space program that we had never had. And out of it came an extraordinary period of good will.

Now this committee a year and a half ago took our Apollo-Soyuz crew to Moscow for a 10-year anniversary reunion with the cosmonauts. And that is a special fraternity, and it was obvious at the greeting at the airport with those families.

We had direct talks, with White House approval, of exchanges of data and information. Rather small steps at first, but we laid out the whole scenario of the possibilities of the future. And indeed, the White House and in part through NASA and the State Department, have followed up those overtures. And they are having ongoing discussions about possible cooperative ventures.

And one of the ones that will be on the list to talk about is the possibility in the next decade where we might go in an unmanned mission to Mars, where it would be a joint mission where one would go and land—one nation—pick up the samples. The other nation would come, land, take the sample and return it to earth. So these are some of the possibilities and they're quite exciting.

All right, Mr. Hayes.

Mr. HAYES. Well, first of all, I want to tell you that I'm delighted with the charts and with the graphs because I did not know until today what that scaffolding at the Capitol was for. Apparently, you intend to construct the manned platform——

[Laughter.]

Mr. STOFAN. Why don't we go ahead and put that one up.

Mr. HAYES. That's phenomenal to me. And don't worry, Nagle won't notice it.

My comments earlier——

Mr. NAGLE. Yes, he will, he wants to know how much it cost.

Mr. HAYES. My comments earlier were intended, not only to set the tone for what, indeed is, in great part for many of us a commitment that isn't measured simply in terms of dollars. I come from a very real world. I was a bank commissioner, look at budgets much, much more intently than probably most people here look at budgets. And I can tell you that the best and most profitable bank in the state of Louisiana is the one that has the highest commitment in dollars to research and technology. And I don't think that's an accident.

And to get back to my question earlier, the $8 billion original estimate was one, as I understand it, that was based upon what has to be, in my impression, no more than an opinion of rather a far step decade down the road. The present estimate, which I know greatly exceeds that, I simply want to know, what have we progressed to? And in what level and degree of confidence? And the question asked without criticism of the process, but requesting an understanding for a confidence level on our present opinion of budget costs.

Mr. STOFAN. Okay, with the set of viewgraphs that I have I will address that exact issue as I go through it. And they're laid out so that, two things, I can address—one is, why we're doing the Space Station. The other one is, where did the original estimate come from and what are the things that were missed or overlooked, or what has changed in the new estimate. And I will address that issue if I can go through the presentation.

Mr. NELSON. Well, can you just give one stab at his question, why 20 billion instead of 8 billion?

Mr. STOFAN. The $8 billion estimate was made when approximately 1/10th of 1 percent of the money was spent on the program. And also it was made at a time when the agency was looking at four different configurations and decided of the four that the one looked more feasible. At that time they said, well, that's about an $8 billion program. And there was no more behind that estimate at that time than that.

There was not a detailed, bottoms-up, deep, analytical evaluation of what the cost was because they were looking at concepts at that time. So it was a cost based on a concept, not a cost based on a firm configuration with all the details and all the back up of a detailed estimating that we have today.

Mr. NELSON. I want to know that this can be pushed, and I made sure that that $410 million request got into last year's budget, and we did so on the basis that the space station, the United States portion of the space station, was going to be $8 billion, and we did so with the commitment that hardware would actually start to be bended in fiscal year 1987. So that the commitment was made to move on. Now can you understand why some of the members of this subcommittee are a little upset when we suddenly start hearing that what we went to the wall for, and made sure that was in the budget last year, in an extraordinary year, that in fact it's not turning out like what we were told.

Mr. STOFAN. Okay, I think I can walk you through that process and tell you where we have come from and where we are today, and why we are confident today, but I'd like to do that because

you're hitting at bits and pieces and I think there's a flow to it that makes some sense.

Mr. WALKER. Yeah, I want to hear the flow, but I think the point that the Chairman makes is a very, very important point. And that is, that we ask time and time again about that $8 billion figure, and at no time did NASA ever tell us that that's an off the wall figure that we basically cooked up to, to give us some guessing range. I mean, your explanation of the $8 billion figure today is, okay, we needed a figure, so we came up with $8 billion, is essentially the point. That is not the presentation that was made to this subcommittee when we were making those commitments. We asked year after year, time after time, is the $8 billion figure a firm figure, and were assured by people in, with some rank at NASA that that was in fact a firm figure, that that is the figure that would, that they were working with, and that that they intended to stick with. And now, all of a sudden, when we come to the point that we have to begin implementing the program, the price doubles. And that's the reason why we're upset. Because it wasn't for lack of asking.

Mr. STOFAN. The guessing was——

Mr. WALKER. Over and over and over again.

Mr. STOFAN. Yeah, the rough estimate the first time was on the very, very first time the $8 billion came out, and again, I can show you how that number evolved. And I'd like to do that.

Mr. NELSON. Okay, proceed.

**STATEMENT OF ANDREW J. STOFAN, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY THOMAS L. MOSER, DEPUTY ASSOCIATE ADMINISTRATOR FOR DEVELOPMENT AND PROGRAM DIRECTOR; AND DR. FRANKLIN D. MARTIN, DEPUTY ASSOCIATE ADMINISTRATOR**

Mr. STOFAN. Okay. Again, I would like to submit the written statement for the record, and before I get into the presentation, I would like to introduce a few people here. To my right is Dr. Frank Martin, Deputy Associate Administrator (AA). To my left, Tom Moser, Deputy AA for Development and the Program Director. Other people who are supporting me today, and I'd like them to raise their hand. Dr. Bill Rainey, Special Assistant; Dr. David Black, Chief Scientist; Mr. Daniel Herman, Senior Engineer; Mr. Paul Anderson, Resource and Administration; Dr. Terry Finn, Policy Division; Mr. Richard Halpren, Utilization Division; Mr. Al Diaz, Strategic Plans and Programs; and also supporting me today is Mr. Ken Pedersen, the Deputy AA for External Relations.

Now this is the new management team that has been assembled since the last time I was here, on board and fully functioning now.

Okay, as you mentioned, the superstructure in front of the Capitol Building. This shows the relative size of the station, about 155 meters wide, or that's like 4½ football fields, by about three football fields high. As I found out over the last six months, the Space Station reaches all the way from the House to the Senate.

Next, please.

Again, this shows an overview of the station, and usually with it, showing a picture of the shuttle in it, you don't get appreciation for how large this facility is. Again, we'll have 87½ kilowatts of power, that shows the two U.S. modules they have in the lab, a European ESA laboratory module, a Japanese module that has both an inside pressurized volume, and an outside area that can be reached by remote manipulator, the Canadian contribution of a remote arm to assemble the Station.

Also, I think it's very important to remember, keep in mind, that the Space Station complex also consists of two platforms. One, coorbiting, that can be serviced, the other one is a polar orbiting platform that the United States provides, and there is another polar orbiting platform provided by ESA.

I think it's important to understand the Space Station infrastructure, and here I'll get into some of the reasons of the cost that we had been talking about, and what perhaps has changed. Normally, when we look at the pictures, and think the Space Station, we think of what is shown on the left as the work package contractors. There's the man-to-base, the two platforms and the initial spares. That is the basic hardware being provided that ends up eventually in orbit.

Now, in the middle, is Space Station support, which is also an integral part of the Space Station, and it is budgeted in my budget. It includes the program support contractor, that's the systems engineering integration here that will support the people in Washington, Tom's organization, and also at the centers. Test beds that exist at every one of the centers, and by a test bed I mean for instance, the data management system test bed at Johnson that has computers and hardware and lines that go out and they test different concepts of how a data management system would work, and try to tie it into all the other systems to see the interaction.

Another example of test bed would be afterwards with the power system, where we actually simulate the solar dynamic, the photo voltaic, and lay out the entire system and trade our components, and not run and test the systems interaction, but begin to develop the computer models, and be able to model the entire system. So every one of the centers has test beds, and that's part of the program.

Integrating facilities, both at the centers, and particularly at the KSC, the launch processing facilities that have to be built and totally outfitted are again included in the budget. Space station control center, or centers, which will be at Johnson and perhaps Marshall, the operations capability development, and that is the funding of all the facilities for testing elements of the Space Station, for training the crew members, et cetera.

Development center technical oversight, and that is each from one of the centers, the continued oversight as the station is being built and support. The TMIS technical management information system, which will be a real technological, I think, step forward in being able to communicate in a near paperless system, where we can communicate between all the contractors, the NASA centers, and with our foreign partners, provide in real time, data that everybody can get their hands on and be able to transmit data, hopefully, eventually, even engineering drawings.

And again, the last one, the software support environment, that is something brand new that has not been done before. That's providing the hardware and software, and software tools, or management plan, that lay the foundation for the development of all of the software on the Space Station including the internationals. So that when all these elements are molded together, the entire space station will play and function as one unit.

Mr. WALKER. How much does all that cost?

Mr. STOFAN. In the center? That part in the center, originally, that on the left and in the center was judged to be approximately $8 billion, except that the center part is where the major portion of the cost increase has occurred. It has not occurred on the left on the work packages. It occurred in the middle. And some of the reasons are, is that the program support contract did not exist at the time, NASA thought that they were going to do the system engineering integration all in-house with civil servants.

Today we are not doing that. The decision was made after the Challenger accident because of the Sam Phillips Committee to do that external. And that's about a half to three quarters of a billion dollars. Also, since the time of the estimating of the original $8 billion, the method of supporting the centers, mainly the manned centers, there used to be a budget line item that would pay for a lot of the base operations. That has essentially disappeared. That costs now fall back onto the programs to pick up, and that was not there at the time. That's about a billion and a half dollar charge against the program that didn't exist at the time the $8 billion was estimated.

The other areas in there as we went along, and defined the Space Station, we realized that there were a lot more facilities and capabilities that had to be built up at the centers and at Kennedy, that were not estimated and looked at in detail, until I came on board in July, so there were things that changed drastically, there were things that were missed, there were things that became better defined over a period of time in that center column, and the majority of the increases in that center column.

Mr. WALKER. Yes, but how much money is the bottom line?

Mr. STOFAN. The bottom line of the—you mean the entire Space Station?

Mr. WALKER. No, the first——

Mr. STOFAN. The first two columns?

Mr. WALKER. The first two columns. Did you put a bottom line of billions of dollars under each column?

Mr. STOFAN. That number is now presently being discussed with the Administation, OMB and OSTP, and I'm not free at this time to discuss that in detail.

Mr. NELSON. Are you directed by OMB not to discuss that?

Mr. STOFAN. I was advised by my boss not to discuss it. [Laughter.]

Mr. NELSON. All right. Mr. Walker.

Mr. WALKER. Well you know, I don't want to—let's go through the presentation, we'll come back and we'll discuss specific numbers and so on, and we'll use the White House figures, all right.

Mr. STOFAN. Whatever ones you like, yes.

Mr. NELSON. Mr. Walker has the White House figures. You can't talk about the White House figures, I will.

Mr. WALKER. We have a very well informed committee.

Mr. STOFAN. Okay now, so on the right hand side is other support that is required for the Space Station that is not budgeted in the Space Station budget. I think it's very, very important to understand, I think, as the Chairman pointed out to start with, that the Space Station is something different than NASA has ever done before. You cannot compare this job to anything else we've undertaken. It is different in that we are establishing the entire infrastructure for building a research center in space that's going to be operated 365 days a year, 24 hours a day, over a 20-year period, and that requires an entire infrastructure to support it, and we've never done anything like that before.

And I think that people keep looking at this as well, this is another spacecraft, like we're going to build another Voyager, that goes to Jupiter or Saturn, and makes a few measurements, it goes on and then is finished. This is a continuing capability for this nation, that will allow people to live and work in space over a 20-year period and acccomplish many different things which I hope I can get into.

But again, on the right, the obvious is the STS launches are in our budget, OMB, the tracking and data, that Bob talked about, data processing for experiments, ground data distribution, payload ops, international control centers which they plan to build, experiments and experiment control and data analysis, all, everything on the chart is necessary to operate a Space Station, but the 8, or the new number is the two columns on the left.

Next, please.

Okay, to get into a little bit again on the $8 billion came out when we had mission analysis studies, and a concept development. Now, that concept development came for different concepts that were being looked at, focused down at the end of that onto one, that's the time the Presidential commitment was made in early 1984.

After that time, we went through a skunk works—that's an internal NASA exercise—and spending some money with the support. And out of the skunk works came what was referred to as the power tower, which you have seen before. From that, we then went into the phase B with the major contractors and the major amount of money being expended into a 21-month study to see again if we got all the contractors involved, and the government agencies, and all of the users and brought them in, for the proper configuration for the Space Station.

Near the end of that activity, as you know, this past fall—late summer, early fall—we came in and stood down the program for 90 days to take a look at the configuration, the assembly sequence and some other problems being encouraged by our good friends from Texas to take a good hard look at what we were doing and to clean up the interfaces between the work packages, which had been a bit fuzzy.

We went through that exercise, and I think it was a very, very valuable exercise to ask us to go back in and look at again. I think out of that came a Space Station that we feel is designed properly.

It suits the scientific and technical needs. It has the work packages and work distribution is now, I think, arranged in a manner that is fair. We feel very comfortable with that configuration.

We immediately at that time then kicked off a cost analysis that—Paul Anderson headed the team and later Tom joined him—to take a good hard look from bottoms up of what would the station really cost. First of all, we had to settle on what it was we wanted to build. Were we really comfortable? Was it the right station? And then come out with a cost. And that cost came out, again, in December, the initial estimates and we have been reviewing internal to NASA for a couple of months, and this has been scrubbed very vigorously by my bosses. We then have reviewed this with OMB and we're now in the White House.

We did continue on with parts of the program, like the program support contract RFP went out on the 3rd. The TMIS and the SSE are out. So we are continuing on with parts of the program. But the four major work packages to build the hardware are held up until we can get the reviews done.

I next would like to address the program management which again has been a total change from what it was before. As you well know, after the Challenger accident and the Sam Phillips committee came in and made recommendations to centralize the management of the program in the Washington area. Level A, NASA headquarters is Frank and my organization where we say that's policy and overall program direction. And that is called—we refer to as up and out. The responsibility of the A office is to work with the other offices at NASA headquarters, the Congress, the OMB and all the other elements to the U.S. government that want so badly to help us build the Space Station.

The level A prime is in the Washington metropolitan area. That is headed by Tom Moser. That has a large group of civil servants and support service contractors. That's the program support contract that will manage all of the pieces. That's the four major work packages, the three internationals and the effort made by the Kennedy Space Center to support his program.

And again, the centers on a day to day basis will manage the contracts for the hardware elements that will be delivered and assembled at the Cape. And also, they manage the end to end systems that cut across the package. Now the only place that all can be pulled together to make sense that it fits together is by Tom's organization, and again, here in the Washington area. And again, we show the contractors down on the left-hand side that will provide all of the various elements of hardware to go together.

It should be pointed out that level C, the NASA centers, they are providing that center column from that other viewgraph of that infrastructure that allows us to operate, train and carry out the entire space station program.

Okay, the objectives are, again to develop a space station by the mid-1990s; useful affordable capabilities. Again, internationals have been baselined as part of it. The things that are, again, different than anything we've tried to do before is design for evolution. We do not expect the first station we put up there will be the end. It will grow. It will grow in capability and number of people.

Also the station is making a real push on automation and robotics, both expert systems and the end effectors that can do things externally without man being involved, or with telerobotics. Again, we are providing for a man-tended concept in the baseline.

Okay, the question is often asked, and again, I think we have been a bit remiss in explaining what it is the Space Station is going to do. And again, I think people are used to looking for one single scientific event or single piece of science that the station will get, therefore, they can understand the justification. The Space Station is a research laboratory that's orbiting the earth. It will do many different things, and we will start out with the micro-gravity area, the sealed volume of the Space Station.

Again, in life sciences, the benefits, the effects that come from low gravity, long duration and all important human presence, enables studies of the fundamental behavior of living cells, enables new characterization of human as a system. Again, which can apply back to things on earth. Enhances understanding of the key physiological effects that can be applied to the better human condition.

And again, the future of NASA, and this was brought up before where the vision, where are our goals, where are we going in the future—we can space qualify the human being so that we can have permanent manned presence and go out to the moon and on to Mars.

In the materials research, again, it's low gravity. Man being there, especially at the beginning is very, very important. You cannot leave these things alone. And again, we need the high power—the 87½ kilowatts that's provided by the station to carry out these experiments.

Again, we can fabricate, for instance, things like defect free crystals of gallium arsenide that can be used in computer and other applications, produce large, pure biological crystals essential to the identification of molecular structure, produce pure crystals for use in scientific and defense related things, arrays and sensors. For instance, we know that the Russians have been conducting research on mercury cadmium telluride.

And again, the characterization of pilot production of lightweight super alloys. Again, it's pilot production, and for quite some time there's going to be a lot of research and technology and materials processing before we can set up production facilities. And the Space Station is absolutely essential to allow that next step.

Also we usually think of the manned, and the station being in the pressurized volume. But that's only one part of the Space Station. Another part of the manned element of the station can provide, on the upper boom, capabilities for—it's an ideal location for telescope, astronomical telescope to search for other planetary systems. It's also an excellent location to conduct long term observations of the sun.

Also for the earth sciences, if you look at the lower boom of the station, the instruments mounted along the bottom, it's ideal for earth viewing. It's in an orbit that crosses the equator, that can look at the tropical rainfall. Again, providing keys to predicting droughts and agricultural problems.

As I mentioned before, the Space Station complex is also made up of platforms, co-orbiting platforms that can be used—and again, this is Bert Edelson who you'll talk to next week—the scientific use of the platform that we're providing can be used for ACSP, which is the next of the great observatories following space telescope and gamma ray observatory, or for instruments like infrared telescope facility.

The polar platforms are part of the space sciences EOS, the earth observational science program that fits into a long term program looking at the earth as an entity, a global entity and trying to understand how that behaves.

Also the platforms are being worked as an intergovernmental in NOAA is planning to put on, not only research instruments but operational instruments that will be used on a day to day basis by the—and benefit everybody in the United States.

Also there's a complementary solar or polar orbiting platform provided by ESA, and I'm sure in the end eventually the instruments will be swapped back and forth because they're in a different time orbit. So that the Space Station is a complex that provides many, many useful scientific, technological and commercial endeavors.

We haven't talked a lot about the last two, the technological. In Ray Colladay's budget, he is going to grow over the next few years to $100 million a year. He has a program laid out in detail that will provide technology money for experiments to go on the Space Station to enhance and advance the technology which will feed right back into our industry.

Also we are working with Ike Gillam in the commercial sector to try to encourage, and we have in our RFPs language that encourage the contractors to bring back ideas to us for the commercialization of the Space Station. So we're reaching out in all these different arenas, and I think that there is more than enough justification what it is we're trying to do with this facility.

And again, I think it is an enabling and essential tool if, again, we have a vision that goes beyond just staying in low earth orbit, it's an essential tool to enable us to do that.

Next, please.

In conclusion then, I think the Space Station is for science and technology. For NASA it's a new way and different way than we've ever conducted business before. And for the United States is an element of a civil space policy for long range goals and objectives. It's a symbol of our commitment to leadership in space.

And again, with what the Russians are doing, obviously if we do not do this and we delay we are turning over permanent manned presence to the Russians in the future. And again, for mankind, we need this if we're going to go to the moon and to Mars, which I believe we will. This is an absolute necessary element to do so.

Thank you, Mr. Chairman.

[The prepared statement plus answers to questions asked of Mr. Stofan follows:]

Statement
of
Mr. Andrew J. Stofan
Associate Administrator
For
Space Station
National Aeronautics and Space Administration
before the
Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

## INTRODUCTION

Mr. Chairman and distinguished Members of the Subcommittee:

The Space Station Program has made significant progress in the last year. This afternoon I would like to review this progress with you, explain the FY 1988 Space Station budget request and continue our discussions with this Subcommittee, whose support and guidance is essential to a successful Space Station program.

Before doing so, let me first comment briefly upon the Space Station, it's significance to science, and its importance to our Nation's future in space.

The Space Station will be a unique and versatile complex - unique because it will provide us with a permanently manned presence in space, versatile because it will provide truly diverse capabilities. This diversity is reflected in the Station's pressurized laboratories, accommodations for attached payloads, and free-flying unmanned platforms. NASA, in cooperation with its international partners, is developing a research laboratory that will add significantly to our storehouse of scientific knowledge. This laboratory will also stimulate new technologies and help realize the potential of commercial operations in space. Combining both manned and unmanned systems, the Space Station will offer an unmatched capability that can evolve in time as new demands and new circumstances arise.

As a laboratory in space, the Station will support research of fundamental importance. The Space Station's microgravity environment, high levels of power, and extended time on orbit, will enable scientists to make new discoveries in materials research and life sciences. Space Station scientists, working within pressurized modules, will be able to fabricate large, defect-free crystals such as gallium arsenide that may lead to new super computers. They will be able to produce pure biological crystals necessary for the identification of basic

molecular structure. Other scientists will be able to study the fundamental behavior of living cells and help characterize and understand the human body as a self contained, complex, ecological system. They also will be able to penetrate further the mysteries of human physiology as it is affected by extended space flight as it is affected by extended space flight.

Yet the Space Station's substantive research capabilities include far more than its pressurized volume. It's free-flying platforms will enhance astrophysics and enable truly synergistic studies of the Earth's atmosphere, land masses, and oceans referred to as Earth system science. Moreover, the Station's external structure, its upper and lower booms, are designed to be stable platforms that will be available for a number of specialized instruments and telescopes. These will look out to the stars and down upon the Earth. The upper boom is an ideal location for an astrometric telescope to search for other planetary systems. Its data will enable us to better understand the origin of our solar system. Other upper boom instruments will focus upon the centerpiece of our solar environment: the sun. Space Station instruments will be able to conduct long term, high resolution studies of the sun's surface and of solar radiation. Besides enhancing our understanding of basic physics, such studies will contribute to our knowledge of the Earth's environment and climate. The Space Station's lower boom is also a platform for scientific observation. Utilizing the Station's orbit, scientists will be able to monitor and examine phenomenon such as the tropical rainfall. This rainfall is a dominant factor in understanding the Earth's hydrological cycle which is a critical element in understanding the periodic variability in the Earth's weather patterns.

However, the Space Station's value extends beyond the experimental and observational sciences. Scientific instruments be they in a laboratory or on a boom, require maintenance, upgrading, repair and replacement. The Space Station we are designing will accommodate these functions. The Station will not only bc a research laboratory of unparalleled capability, it will, because of the manned presence, be a servicing center of considerable practicality. Our experience in space to date confirms the importance of accommodating these functions. Things do break and they don't always work exactly right. They need "time in the shop." The Space Station will be that shop. It will be able to service the scientific instruments it carries as well as provide for extended service of free flying spacecraft that are co-orbiting.

Perhaps the most significant feature of the Space Station, essential to its utility for both science and technology, is the permanent nature of its crew. Men and women will be aboard the Station base full time, 24 hours a day, 365 days a year. This makes the Space Station different from what we have done in the past. It makes it a system of enormous capabilities. Humans are the most sophisticated machines of all. Their creativity, their

dexterity, their ability to perceive, to interact with instruments and to respond to the unexpected are unique and essential. The Space Station will be designed to exploit these human capabilities. And by providing a permanent presence, the Station will enable these capabilities to realize their fullest potential.

Mr. Chairman, let me now speak to the Space Station from a somewhat different perspective.

The Space Station represents a commitment to leadership in the future. Today, United States leadership in space is being challenged. Spacecraft and launch vehicles of considerable sophistication and proven reliability have been developed and flown in Europe, Japan, China, and the Soviet Union. These countries understand the utility and value of space systems. They understand that profit, productivity, prestige and national strength are the products of a space program. They are committed to an extensive and visible presence in space. Our response must be to press forward with projects that are intellectually significant, technically demanding, and genuinely useful. Often, we will do this together with our friends and allies, in cooperative endeavors. Sometimes we will do it by ourselves. No nation can match our experience in space or our technical capabilities. If we apply these with vision and imagination, if we chart the future with programs such as the Space Station -- with its range of capabilities unlike any other space system -- then leadership in space will again belong to the United States.

## OVERVIEW

The past year has seen a number of significant steps in the Space Station program. Before reviewing with you our accomplishments of last year and our plans for the year ahead, let me discuss these improvements with you for they represent significant progress. Dramatic steps in program management and organization, configuration, operations planning, cost projections and procurement planning have occurred. Each is important. Together they provide the basis for a successful development program.

## PROGRAM MANAGEMENT AND ORGANIZATION

As the Space Station program matured, it became evident that the management approach used during the definition phase would need to be restructured for the development phase. This was not unexpected; initial organizational structures of large complex aerospace projects traditionally evolve over time, just as the technical parameters of such projects change. Given the breadth and depth of the Space Station program, it became imperative that a strong and stable organization be in place to manage the program during the detailed design and development phase.

Late last summer a new Space Station organization was established. It features a centralized management structure, highlighted by a new technical program office now being established in the Washington D.C. area. This program office reports to the Office of Space Station at NASA Headquarters. The new organization should be viewed in the context of three events which shaped the program's new structure:

- The extensive Space Station definition and preliminary design studies we initiated tested management approaches as well as technical design approaches
- The Presidential Commission investigating the Challenger tragedy recommended that NASA overhaul its management structure and processes and strengthen the role of NASA Headquarters.
- An independent review of the Space Station organization by a team of experienced aerospace managers, led by General Sam Phillips, recommended fundamental changes to the organization.

Dr. Fletcher approved the new organization for the Office of Space Station on December 23, 1986. Principal functions of the Office of Space Station organization, which I head, are policy direction, budget formulation, and external affairs. These are essentially "up and out" functions. In contrast, the Space Station Program Office organization will be responsible for the overall technical direction and content of the Space Station program, including systems engineering and analysis, program planning and control, resource and configuration management and the integration of all elements into an operating system. I describe this as the "down and in" function. Both areas of responsibility are closely coordinated in order to assure effective management.

The Space Station work packages are heavily interdependent and the resultant interfaces have a high degree of functional complexity. This demands a strong systems engineering and integration capability. The Space Station Program Office organization, supplemented by a support contractor, will provide this capability.

Considering the strong imperative to achieve economy as well as authoritative central control, it is important to use the NASA field centers' institutional capabilities that exist rather than to attempt to duplicate them. The systems engineering activity will be conducted in part through the NASA field offices.

I believe that we have created a management and technical structure for the Space Station program that will:

- provide leadership to the project with clear lines of authority and accountability;

- maximize the use of the capability and competence that exists at each participating NASA Center;
- most efficiently integrate the complex work package elements;
- react effectively to changing conditions during the development process; and,
- result in the development of a safe, reliable, and cost effective Space Station.

CONFIGURATION

As you are aware, Mr. Chairman, we have derived a new Space Station baseline configuration. This strongly supports identified user functions; addresses the crew concerns that arose both before and after the Challenger accident; provides for early user payloads; and results in an assembly sequence that is consistent with the Space Transportation System (STS) capability. We have also selected subsystem designs which are intended to reduce the operational life cycle costs e.g., closing the loop on the environmental control and life support system (ECLSS), solar dynamic power, and a lower operating altitude.

The "dual keel" configuration represents a sound design to which considerable analysis has been applied. It is an extremely capable configuration; one that balances technology, user requirements, and program costs.

As a consequence of the intensive systems definition and preliminary design activity, a Space Station configuration was developed last year that itself effectively addressed many requirements. The changes brought about to reflect lessons learned from the Challenger accident and a management and technical review caused us to reevaluate this configuration. In addition, there were constructive concerns raised by members of Congress and the astronaut office. The thrust of the concerns associated with our baseline configuration were:

- an optimistic set of assumptions regarding the STS capability;
- a baseline design that demanded a large degree of extra vehicular activity (EVA);
- an assembly sequence that could not accommodate early delivery and operations of scientific instruments; and,
- a potential for insufficient power to support early user activities.

NASA and the Space Station Program Office listened to these criticisms and, at the direction of the Administrator, organized

a full evaluation of the original dual keel baseline configuration. The Office of Space Station chartered a Critical Evaluation Task Force (CETF) to conduct this evaluation. This task force suggested modifications to the configuration and also recommended a revised assembly sequence. The findings were presented to senior NASA management and the revised baseline configuration was concurred in by the Space Station Office and later approved by Dr. Fletcher.

This revised baseline is similar to the original dual keel baseline from an overall development standpoint. This is not surprising since the original configuration reflected user requirements, international considerations, effectively balanced technology, and budgetary considerations. However, shortcomings in the earlier configuration were corrected:

- The inclusion of resource nodes significantly reduced the need for EVA for assembly and maintenance and resulted in more space within the laboratory and habitation modules.
- The delivery of the first user instrument on the third assembly flight assures the Station can be used for scientific purposes very early in the assembly sequence.
- Following the second assembly flight there will be 37.5 kW of available power thus providing an ample level of power for early users.
- The full construction of the dual keel occurs subsequent to the achievement of the permanently manned capability (PMC) which permits laboratory activities earlier in the assembly sequence.
- The overall assembly sequence now requires 17 assembly flights which is consistent with a more conservative projection of STS capabilities.

As part of the CETF activities, and as an extended consideration therefrom, the Space Station program also conducted special studies this year to investigate the potential use of expendable launch vehicles (ELV's) including heavy lift launch vehicles (HLLV's). In each study the use of the ELV's was found to have potential value in accelerating the achievement of major Space Station assembly milestones; however, certain problems and complications are involved with each potential utilization.

## OPERATIONS PLANNING

To guide the next and more detailed planning for Space Station operations, we have completed an Operations Management Concept which is intended to promote maximum user autonomy and cost effectiveness through simplification of the management structure. The review of this concept was comprehensive, involving our international partners and the user community. While gratified by the acceptance of this first step towards an operational plan, we became aware of the need to retain the broadest possible base of participation and input as our work progressed. As a result, in September 1986, I established an Operations Task Force to provide advice on how best to implement the Operations Management Concept. This group, which includes members from all organizations within NASA and the user community, both domestic and international, and which has involved industry, academia, and other parts of the private and public sector, have provided inputs to the RFP process. They will then provide their recommendations this Spring in time to influence both the utilization and operations capability development effort as well as the design of the Space Station itself.

## COST REVIEW

A thorough reassessment of the estimated costs for the Space Station was requested in August 1986 by the NASA Administrator. Prior to the initiation of Space Station development, Dr. Fletcher wanted to be able to present to the Administration and Congress cost estimates for the Station to which he could commit with confidence.

The cost study provided the first extensive look at the projected costs of the entire Space Station program. It is based on the new baseline configuration recommended by the CETF and utilized contractor and NASA databases, including the data acquired during the definition phase of the program. The impact of the management/organization changes recommended by the Phillips Committee were also taken into consideration.

Together with the definition analysis, the cost review provided us with thorough, complete, and reliable cost data for the Space Station.

The cost review was a major undertaking. A special team of technical and cost program and resources experts was established to carry out the review which lasted three months. Special reviews with the Space Station project offices at the various NASA centers were held, as were reviews with the definition phase Space Station contractors. Definition phase analyses were utilized and NASA's wide program experience was tapped. The cost review focused primarily on the development program, but took into consideration operational aspects of the program as well.

The cost review has now been completed. A number of meetings with Dr. Fletcher and Mr. Myers -- at which recommendations were made -- have been held. The Administrator and his Deputy are now discussing the cost data with senior officials in the Administration at the conclusion of which we will be in a position to discuss our analysis and conclusions with the Committee. I look forward to having these discussions with you and to reviewing the material in depth. I fully understand that your continued support of the program is dependent upon a full and complete explanation of the new program cost estimates.

PROCUREMENT PLANNING

Our Space Station definition and preliminary design efforts coupled with the CETF activity resulted in documentation containing detailed requirements for all aspects of Space Station design and are the bases for the Requests for Proposal (RFP) written for the detailed design and development phase of the Space Station.

The RFPs have been carefully coordinated. The four work package Centers' work statements have been reviewed to clarify inconsistencies, overlaps, or omissions. Common language has been incorporated into the RFPs for general requirements applicable to all. In addition to the individual Source Evaluation Boards (SEBs) at the NASA Centers, a Space Station Program Procurement Coordination Committee, which includes senior program management, has been established to coordinate the work of the Center SEBs and to make decisions as necessary.

In addition to the design and development RFPs, the Space Station program developed, along the lines as described above, an RFP for a Program Support Contractor (PSC). This RFP was released to U.S. industry on February 3, 1987. The selected contractor will support all aspects of the program office activities, but the largest part of the effort will be systems engineering and integration. This contractor will support the NASA Space Station Program Office in the Washington D.C. area as well as the Program Manager's field offices to be established at five NASA centers. The main focus of the PSC will be to assure the integration of the various subsystems into the Space Station system. We expect contractor selection by August 1987, with the Program Office and field offices fully operational shortly thereafter, in readiness for the start of the hardware contracts.

The data management and information systems activities include the establishment of the Technical and Management Information System (TMIS) and the Software Support Environment (SSE). During the past year, in addition to maintaining a limited information management capability in support of definition activities, we completed a functional definition of TMIS and released an RFP for a systems integration contractor to design, acquire, and implement TMIS. Proposals are under evaluation and we expect to award a contract in May. TMIS will be implemented in increments

and the first increment, which will include existing Space Station program resources will be operational by December 1987. Additional increments of capabilities will correspond to the requirements of the program as the development of the Station proceeds.

The Software Support Environment (SSE) is an important key to the successful development of the initial Space Station program and its longer term, cost-effective evolution. The benefits from the SSE can only be realized if that environment is in place and available before its capabilities are needed by the program's software development commun..y. During FY 1987 we, therefore, moved aggressively ahead with the procurement of an SSE system contractor. It is important to emphasize that the SSE is truly a program-wide initiative. The RFP was issued for industry response in September 1986. At the present time, the proposals submitted by industry are under evaluation by a program-wide SEB. We are on schedule in the procurement process and plan to recommend an industry source to the NASA Administrator in late Spring with a contract start in the May-June 1987 timeframe.

The Flight Telerobotic Servicer (FTS) is a highly automated telerobotic device capable of precise manipulations in space. Congress has directed us to develop such a device, which is now part of the baseline configuration. Available, more importantly, for Space Station assembly and operations, the FTS and its technologies are expected to have wide applications in both space and on the ground. The principal activities planned for this year are the preparation of a Preliminary Program Plan and the conduct of an in-house preliminary definition study leading to the issuance of a competitive solicitation for a nine-month preliminary design and definition study. This RFP is expected to be issued in April 1987. Contract award is planned for the beginning of FY 1988.

## HIGHLIGHTS OF FY 1987

The depth of the Space Station program is best illustrated by our accomplishments. I would like to review a few of the highlights of the past year.

### SYSTEM DEFINITION/PROGRAM MANAGEMENT AND INTEGRATION

In December 1986, we reached a major program milestone: the conclusion of the twenty-one month contractor effort of the system definition and preliminary design phase of the Space Station program. This effort began in April 1985 and involved NASA Centers: the Marshall Space Flight Center (MSFC), the Johnson Space Center (JSC), the Goddard Space Flight Center (GSFC), the Lewis Research Center (LeRC), and the Kennedy Space Center (KSC), as well as eight contractor teams. Other support activities have been conducted by the Ames Research Center (ARC), the Jet Propulsion Laboratory (JPL), and the Langley Research Center (LaRC).

During this period, each center with its respective contractor teams conducted in-depth trade studies, analyses and assessments of its assigned portion of the Space Station. This process involved comparisons of subsystem designs, components and technologies with respect to the major, overall requirements such as user accommodations, safety, reliability, ease of maintenance, high productivity and lowest life-cycle costs.

The results were submitted to the Space Station Control Board (SSCB), with representation from the user community; the operations planning community; safety, reliability and quality assurance; international partners and other communities important to the overall Space Station design. This review process determined the baseline configuration which has become the basis of the Request for Proposals (RFPs) for detailed design and development of the Space Station.

It should be noted here, that the results of the CETF activity, which I have previously described, were accepted by the Administrator and were incorporated into the current requirements documentation.

Three examples of major decisions during the twenty-one months of definition and preliminary design are:

1. The adoption of a hybrid power system consisting of 37.5 kW of photovoltaic solar arrays and 50 kW of solar dynamic. The lower life cycle cost and more favorable growth characteristics of this system justify this decision. This hybrid power system provides enough power to permit early user operations while assembling the Station.

2. The change from hydrazine to a hydrogen/oxygen propulsion system for reboost and reaction control. Since these fuels can be generated on orbit by water electrolysis, only water needs to be resupplied. Water is likely to be available in abundance due to the materials processing activity requirements. Minimizing the amount of hydrazine, a highly corrosive and toxic fluid, is another benefit of this decision.

3. The closure of the environmental control and life support system (ECLSS). This application of advanced technology is one that will make the Space Station a more viable entity from a logistics resupply cost point of view. Both air and water will be regenerated from metabolic waste and hygienic water, necessitating the resupply of only food and nitrogen. The decision to use an earth-like atmosphere was made to allow life science experimenters to use valid control experiments on the ground.

These are but a few examples of the decisions that reflect the Space Station program's concern with the wishes of the users, the safety of the crew, and efficiency in operation.

ADVANCED TECHNOLOGY DEVELOPMENT

During FY 1987, the advanced technology development effort for the baseline Space Station will come to an end. This program has been conducted in conjunction with the Office of Aeronautics and Space Technology since 1984. This work has been successful in increasing the acceptance of new technology into the Space Station preliminary design. As a result, the expected performance of the Space Station has been enhanced. A few examples of new technologies that are included in the preliminary design as a result of the Advanced Technology Development Program are:

- o solar dynamic power generation;
- o power management and distribution at 20 kHz;
- o two phase heat transport and dissipation;
- o closed loop life support;
- o high pressure, high mobility EVA suit.

The final measure of the success of the technology program will be the performance of the Space Station on orbit. I expect however, that increased confidence will be achieved throughout the development program with the prototyping and selective STS flight experimentation of some of these technologies. It will be at those points in the program that reduction in development risk achieved by these advanced development activities will become more apparent.

The definition phase of the program will be concluded in FY 1987. It provides a solid foundation and justification for the FY 1988 budget request for the Space Station detailed design and development. The advanced technology work and the aerospace contractor's studies were essential to establishing the baseline configuration.

Mr. Chairman, I would now like to describe the program areas we plan to fund in FY 1988.

BUDGET SUMMARY

Mr. Chairman, the budget request I am presenting today will support substantial and steady progress in the Space Station program. With this level of support, we can maintain the program's considerable momentum and meet the President's goal of establishing a permanently manned presence in space by the mid-1990's.

Our total FY 1988 budget request for Space Station is $767 million. This level of funding will allow us to continue our development of Station systems and elements including the FTS, and support the goal of a permanently manned Space Station in the mid-1990's.

It will also provide funding for operations definition ($7 million) to plan for an efficient flow of ground and flight systems during the operational phase and transition definition ($5 million) that will cover studies leading to a logical and orderly evolution of Space Station systems into the next century.

The request for development funding of $733 million will provide for the development of pressurized laboratory, habitation and logistics modules at $196.5 million; assembly hardware and related subsystems at $204 million. It will also support the detailed design and development of the co-orbiting and polar orbiting platforms and platform servicing at $59 million; the power systems at $88 million; operations capability/utilization at $52 million; and management and integration at $133.5 million. In addition, our request contains $22 million for the FTS. Attached to this statement is a chart which summarizes our FY 1988 requirements and our use of funds previously made available.

PROGRAM DEVELOPMENT ACTIVITIES

The $733 million requested for development funding is essential. Together with the initial funds provided last year, we will use these funds to conduct the detailed design of the Space Station, focusing upon elements and systems.

The Space Station development phase comprises four major hardware-related projects and two major supporting development activities. Hardware development includes pressurized modules, assembly hardware/subsystems, platforms and servicing equipment, and the power systems for the core station and platforms. Supporting development activities include operations capability/utilization and management and integration.

The design, development and production activities associated with pressurized modules provide the pressure structures and outfitting for the laboratory, habitation and logistics modules, the pressure structures for the resource nodes, the environmental control and life support system, manned systems, and the components for the internal thermal control and audio/video systems. Launch package integration is also provided.

Assembly hardware/subsystems include the dual keel truss, outfitting of the airlocks and resource nodes, the mobile base for the mobile servicing center, propulsion, external thermal control, data management, communications and tracking, guidance, navigation and control, extravehicular activity, and launch package integration.

The platforms and servicing activities include the design, development and production of two unmanned platforms, one polar orbiting and one co-orbiting; a servicing facility; payload accommodation equipment and coarse pointing systems.

As noted before, the Space Station will utilize an 87.5 kw hybrid power system, with power produced by both photovoltaic arrays and solar dynamic converters. The polar orbiting and co-orbiting platforms will use photovoltaic arrays for power production and batteries for energy storage which are common with those used on the manned base. Space Station power system requirements include the design, development and production of photovoltaic and solar dynamic power modules, common components for the polar and co-orbiting platform power systems; the 20 kHz power management and distribution subsystem and components; and, flight, application and ground support software. Also included in the power system requirements is launch package integration.

The first of the supporting development activities is operations capability/utilization. In FY 1988, NASA is requesting $52 million for this work. In conjunction with the Operations Task Force recommendations, we will continue the planning of the operations structure for the Space Station and begin development of the top level plans and procedures for the utilization and operations phase of the program. The detailed design and development of the institutional hardware and software, exclusive of those items funded under the Construction of Facilities (CoF) budget, required to outfit operational facilities for support, training, and launch site ground processing are funded in this budget line. Utilization supporting development activities build upon the efforts initiated during the definition period, and include the development of procedures, tools and equipment to fully integrate the user into the design and operation of the Space Station's flight and ground systems. User requirements and payload selection processes will also be developed.

Management and integration is the final supporting development activity, and includes systems engineering and integration (SE&I), data management and information systems, program support, and safety, reliability and quality assurance. The SE&I activities will be managed by the Space Station Program Office here in Washington. The program office will be supported by the program support contractor with some effort distributed at each major center involved in the Space Station Program. SE&I activities include the establishment of design requirements, the development of integrated engineering models, systems engineering analyses, resource allocation trade studies, and the allocation of requirements among program elements. At the system level, SE&I will maintain key schedules and documentation, refine assembly and checkout logic, and establish interface verification and control requirements and procedures.

The data management and information systems activities will be a major program activity in FY 1988. In FY 1988, we anticipate significant TMIS capabilities will be added and existing capabilities will be enhanced. More functional areas will be supported, additional databases and applications will be developed, and we will expand the integration of TMIS capabilities with other Agency capabilities.

For FY 1988, $35.4 million is requested to enable the SSE contractor and NASA to implement the first, interim version of the SSE. This capability will be used immediately to support remaining work on the Space Station program requirements, preliminary design, and development of models and simulations. It is very important that the program maintain its SSE momentum during FY 1988 so that the program's extensive and diverse software efforts begin by using a common approach and foundation. The timely support of the program with the SSE capability is expected to produce significant cost avoidance in two primary areas. The first of these is the cost of producing safety oriented, carefully verified software to operate the Station. This will be a challenging task when you consider the software originates in widely diverse organizations. The second cost savings is in the sustaining engineering of that software over the expected life of the Station.

With respect to the Space Station Information System (SSIS), our plans for FY 1988 are to continue the refinement of the SSIS. This will occur through adjustments to the presently baselined SSIS architecture and the specification of requirements into the systems that in turn comprise the SSIS. A key to our FY 1988 success will be continued close coordination with our colleagues from other NASA Headquarters organizations, primarily the Office of Space Science and Applications and the Office of Space Tracking and Data Systems. This activity will interact significantly with the program support contractor (PSC).

Program support will be provided by the individual NASA centers, and will include the management, technical and institutional support necessary to sustain the Space Station development activities.

Safety, reliability, maintainability and quality assurance activities will place an early emphasis on the development of criteria to perform critical design safety reviews at the black box and system levels. This criteria will be used to assess the proposed design of the Station during the preliminary design review. Quality assurance standards will also be established.

FLIGHT TELEROBOTIC SERVICER

As you are well aware, Mr. Chairman, FY 1988 funding is also requested to continue the definition and preliminary design of the Flight Telerobotic Servicer (FTS). The FTS will be a highly automated telerobotic device used to assist in assembly and servicing operations. It will be capable of precise manipulations in space, and will operate with a mix of remote and supervisory controls by the crew. The FTS program is being coordinated with the Space Station launch schedule, and is structured to provide phased capabilities based upon assembly, servicing and maintenance needs. As mentioned earlier, work will continue on the definition and design of the flight and ground

systems and on requirements definition for an STS flight demonstration. The funding requested for FY 1988 is $22 million.

OPERATIONS DEFINITION

We must now turn to planning the ways in which the structure for conducting operations can be used in the development of flight hardware and ground systems. We must also prepare for the execution of actual Space Station operations beginning with the on-orbit assembly flights. Accordingly we are requesting $7 million for Operations Definition in FY 1988.

This request includes a variety of operations oriented study activities that are required to support the development of both flight hardware and operational facilities. Our FY 1988 activities will be concentrated primarily in the area of integrated logistics support. Using information generated as part of the development effort at the work package centers and by the development contractors, specific logistics requirements will be considered and integrated in a structured manner into a program wide logistics support plan. Logistics support requirements must be defined early in the development phase and factored into the design and development of the hardware projects and the launch site in order to ensure an efficient design and reasonable life cycle costs. Our integrated logistics support activities include the initial establishment and analysis of logistics support requirements and the development of a maintenance concept. Other activities include studies of applications of automation and robotics to operations.

TRANSITION DEFINITION

FY 1988 funding of $5 million is requested for transition definition activities, conducted in parallel with the Station development phase, to ensure that the initial Space Station design will facilitate evolution to accommodate increased user requirements. The FY 1988 start will provide the minimum lead time required to demonstrate major new technologies prior to their incorporation in the evolving Space Station system. Transition definition studies will include mission and systems analyses to define evolution requirements, analyses to establish growth modes which optimize user accommodations, and technology forecasts to enable upgrades that will increase Station efficiency and productivity.

The objective of the initial systems studies is to review and understand options for Space Station evolution, rather than to define a specific evolution configuration. Systemic studies of the evolution options provide the knowledge necessary to (1) assure that the initial Station design includes the appropriate provisions for evolution; and, (2) identify the technologies that must be developed. The evolution options are based on potential uses of the Station in the late 1990's and beyond. Options to be

studied include an increased emphasis on research, increased commercial participation, and potential new initiatives such as a lunar base or a Mars mission.

The Space Station program has investigated the potential for the Space Station to support future manned missions. This year a special team conducted a preliminary analysis of the accommodation of a future Mars mission.

The preliminary analyses indicated that crucial technical experiments in the areas of life science, expert systems, ECLSS, and transportation must first be conducted. Our Space Station concept is an ideal laboratory to conduct these experiments. The Space Station could be an essential enabling capability for any manned missions of the future.

The budget requested covers both the evolution studies and the technology systems development. Evolution and technology development plans will be developed to enable a comprehensive program of evolution technology development for both software and hardware to begin in FY 1989. This planning process will be conducted closely with the Office of Aeronautics and Space Technology. The integrated program will result in the development of high leverage technologies while the options for evolution of the infrastructure are kept open for future decisions.

## THEMES

I would now like to discuss our activities over the past year along the lines of the dominant themes in the Space Station program.

### UTILIZATION

A basic objective of the U.S. Space Station Program is to ensure that the facility, as designed and built, will be readily accessible and responsive to the needs of the people who will be using the Station. This is such a straightforward, simple statement of intent that its ramifications may be overlooked. Nonetheless it has already had significant impacts on the Station design and operations planning.

During the definition phase of the Space Station program, the process of collecting user requirements began with the involvement of internal NASA Program Offices -- the Office of Space Science and Applications, the Office of Aeronautics and Space Technology, and the Office of Commercial Programs. These Offices initially represented the four identifiable uses of the Space Station namely, scientific, technological, industrial, and operational. An initial database was established and the design concept of the Station at that time was tested. Outside users were organized and consulted with on their requirements, leading to the formation of activities such as the Task Force on

Scientific Uses of the Space Station (TFSUSS), the Strategic Planning Group for Advanced Technology, as well as the Commercial Advocacy Group within the Space Station Office itself. These groups continued the oversight of requirements for the manned base and the platforms. They were also instrumental in obtaining the modifications to Station design. The changes in systems, such as power, can be directly traced to the impact of the users' requirements upon the design. The changes in element structure, such as the dual keel truss, is directly attributable to user requirements for attached payloads.

The history of the polar and co-orbiting platforms follow a similar pattern. The user's imprint is clearly discernable there. In addition to the uses planned for the manned base, the platforms incorporate a fourth use - operational capability. The National Oceanographic and Atmospheric Administration (NOAA) is planning to use the polar platform and have added their unique requirements to the database. As the involvement of international users became clearer, and the European Space Agency studied the investment in a polar platform, an informal international users group was formed to assist in common platform design and operations. As additional users are identified, it is expected that this group will expand accordingly. Once the process of selection of the actual experiment and instrument hardware begins to be made, a more formal structure will be given to this group, as well as to the users of the manned base.

The emphasis on utilization depicted during the definition phase will continue throughout the development phase. I intend to assure the integrity of a facility that is first and foremost responsive to the user community.

INTERNATIONAL

The objective of significant international participation in the Space Station program, established by President Reagan at the outset, continues as one of our highest priorities. As we approach the initiation of hardware development activities in the United States, we are optimistic about the prospects of corresponding development activities being initiated by our partners: Canada, Japan, and member states of the European Space Agency.

Over the past year, substantial progress has been made in defining meaningful participation. As provided in our definition phase agreements with each of our partners, we reached agreement last year on those program elements each partner would carry into preliminary design to form the basis for cooperation in the development, utilization and operations phases.

Our program level agreement with the Canadians calls for Canada to perform preliminary design of a Mobile Servicing Centre (MSC) for Station assembly and maintenance, attached payload servicing, transportation on the manned base, deployment and retrieval

activities and to work with the U.S. servicing facility as well supporting extravehicular activity. NASA will provide the mobile transporter which will serve as a mobile base for the MSC. As an adjunct to the MSC, Canada is also studying an MSC Maintenance Depot. On behalf of member states, the European Space Agency is performing preliminary design on a Columbus pressurized laboratory module with facilities for fluid physics, life science and materials science. Under the terms of the NASA/ESA Program Level Agreement, ESA is also performing preliminary design on a polar platform primarily for earth observation. Additionally, ESA and NASA are jointly studying an ESA Man-tended Free Flyer to assess its potential impacts and benefits to the cooperative program. Japan is performing preliminary design of a pressurized laboratory module for general science and technology research known as the Japanese Experiment Module (JEM). The JEM consists of a pressurized laboratory plus an attached, exposed facility with a fixed manipulator and large scientific airlock. The Japanese concept also includes an Experiment Logistics Module (ELM) for the resupply of JEM experiments.

Negotiations for the forthcoming development and operations phases began with each of the three partners this past June. These negotiations are proceeding at two levels. On a government-to-government level, negotiations led by the Department of State are proceeding for a government-to-government level agreement to establish the political framework and legal regime for the program. NASA is supporting the State Department in these negotiations. At the agency-to-agency level, NASA is leading the negotiations with counterpart space agencies and ministries to establish agreements for the implementation, management, utilization and operation of the program. A U.S. interagency review of the government-to-government agreement was completed in January of this year and a new draft agreement based on this review was circulated to the partners in early February.

A multilateral session to discuss the revised draft was held in Washington, D.C. on February 11 and 12, 1987. The partners reaffirmed their intention to cooperate on the basis of genuine partnership pursuant to agreements for participation in a civil Space Station program and expressed their intention to continue negotiations.

The Space Station is a civil endeavor. President Reagan approved the program on the basis of civil requirements and NASA, as a civil agency, will design and operate the Station complex. Because the Space Station clearly will be a national asset, we have consistently stated that the Department of Defense, like any other U.S. government user, might well utilize Station capabilities. At present, the Defense Department has identified no requirements for such capabilities. Our policy is simply to assure that options for using the Space Station for national security purposes consistent with our commitment to the peaceful use of outer space are retained. The agreements currently under negotiation with our Space Station international partners reflect this policy.

The negotiating approach of the United States is to establish in the agreements clear definition of responsibilities for the development phase with overall responsibility for the program resting with the United States. The agreements will also establish clear mechanisms for working relationships in the operational phase. A multilateral management mechanism is proposed for the operational phase. The goal is an allocation of Space Station resources and operational costs which is fair and equitable to all partners. We believe that through this process we can ensure that the United States will receive substantial benefits commensurate with its investment and responsibilities in the program. Our goal is to have all agreements in place by the initiation of the U.S. hardware contracts later this year.

OPERATIONS

An essential part of the definition and development phase is to begin preparations for actual utilization and operation of the Space Station. We will put in place the facilities, systems, equipment, plans, and procedures necessary for flexible, user-responsive, and cost effective operation of the Space Station. In designing, developing, and planning operations for the Space Station, we must focus on the ways in which life cycle costs can be held to a minimum consistent with safety and utilization goals. Our plans for achieving this utilization and operational capability will draw on the results of the definition and preliminary design studies as well as our work on life cycle cost management and operations management concepts.

Mr. Chairman, in FY 1987 we will complete the definition of requirements for operational facilities including those needed for space and ground operations, launch site processing, and training. We also completed the definition of program wide requirements for an integrated logistics support system. We have continued our work on life cycle cost management and will report to the full House Committee on Science, Space and Technology later this year. Before the award of the development contracts, we will submit to the Congress the results of new work in this area. The tools developed as a part of this effort will allow us to evaluate the effect of engineering decisions which will be made during the design of the Space Station on life cycle costs.

AUTOMATION AND ROBOTICS (A&R)

The Space Station Program is committed to an aggressive application of Automation and Robotics (A&R) in both flight and ground systems. Effective incorporation of A&R technology throughout the program will improve the effectiveness of the Space Station through increased mission safety and mission capability, while providing improved operational efficiency. The human-in-space will be more free to investigate his new frontier by entrusting daily operations of the Space Station complex to machines.

NASA has three primary thrusts in research and development which apply A&R across the Space Station program. The showcase in this area is the Flight Telerobotic Servicer (FTS). As noted earlier, the FTS will be a significantly automated device which will improve the efficiency and safety of Space Station related operations. The FTS capabilities could eventually evolve from relatively simple tasks to increasingly sophisticated ones.

NASA's second thrust develops candidate concepts for a baseline capability in A&R for Space Station systems. Definition studies have identified optional capabilities which can be applied initially, then incrementally augmented during the Space Station's growth through the use of "hooks and scars". The initial Space Station will operate with significant levels of automation.

For the third thrust, NASA plans to extend this baseline A&R capability throughout the Space Station's growth. This work identifies valuable targets of opportunity in A&R for the growth Space Station and applies them to the program through a process of technology development, demonstration, and application. The Office of Space Station and the Office of Aeronautics and Space Technology cooperatively fund the development of these growth A&R opportunities.

COMMERCIAL DEVELOPMENT

The Space Station Program Office recognizes the potential for commercial participation in providing Space Station systems and services. By commercial participation we mean privately financed and developed Space Station systems which are incorporated into the program to satisfy user demand for Space Station services. The prerequisite is a traditional business one: demand for Space Station systems and services must exceed the supply of those systems and services, creating a market and hence, a business opportunity. The market could consist of both government and non-government users.

The Space Station, as a multi-purpose facility designed to meet the requirements of a broad spectrum of users, is a research and development facility in space. Opportunities for commercial benefit are real but may be long term in nature. Great success by just one set of users, commercial materials processing for instance, could spur the demand for additional space facilities and resources which could quickly exceed currently projected available Space Station resources, thereby creating the necessary market.

Industry could fill this gap. The question is one of timing. We believe the most likely scenario for incorporating industry participation is during the program's growth phase.

The Space Station Program recognizes this potential and, consistent with government policy, encourages industry to consider participating in the program. We have:

well as the Congress and the Administration, have an opportunity to assure that competitiveness is duly served in terms of the capabilities and opportunities afforded by the Space Station program. Collectively, we must assure that our individual roles are melded into a responsible "next logical step" for the American space program.

The Space Station program provides us with the opportunity to build on our accomplishments of the past and press on to our accomplishments of the future.

- established policy guidelines for commercial participation,

- signed an MOU with Space Industries, Inc., of Houston, to exchange information regarding our respective programs, and

- included in the development RFP's, instructions to the bidders to propose two plans to assist us in our efforts to promote opportunities for the commercial development of space.

The RFP requirement is important in that it prepares us for the future. The first plan required of the contractor is how the contractor will assist us in integrating a commercial element into the overall program. The second plan focuses on how the contractor proposes to stimulate U.S. private sector investment and involvement in the program should a market for Space Station systems and services develop. It is our expectation that just as the Air Force medium lift vehicle (MLV) procurement will undoubtedly provide a production base that could benefit the selected contractor in providing commercial launch services, the Space Station procurement could provide a technology base that could benefit selected contractors in providing commercial services on orbit.

Your Committee, Mr. Chairman, as well as others in the Congress have expressed particular interest in various aspects of the program. These include operations planning, scientific return, automation and robotics, and work package distribution. This interest is represented in part by the various reports which have been submitted to Congress over the past year as well as those in preparation for transmittal. I would like to mention just one of these at this time.

DETAILED DEVELOPMENT PLAN

A Detailed Development Plan is in preparation and will be submitted to the Committee, as requested, prior to initiation of hardware development. The plan will identify critical milestones, specify the delivery of products and systems and review technical interfaces. It will also discuss our management philosophy. The plan will provide the Committee with a complete but concise description of how we intend to manage Space Station development. Additionally, each Space Station field office is preparing a project plan for their respective work package and integration activities.

ADVISORY STRUCTURE

During the entire period of formalizing the definition of the Space Station, advisory committees have played an essential role, providing advice and assistance that was unavailable by any other means. Under the auspices of the NASA Advisory Council, the agency has received advice from the standing advisory committees on Space and Earth Science, Life Science, and Space Systems and



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Technology on how to get the most effective use of the Space Station. In addition, two task forces were specifically created to provide advice relevant to the Station: Commercial Use of Space; and Scientific Uses of Space Station. Various groups of the National Academy of Sciences, National Academy of Engineering, the Institute of Medicine, and the National Research Council have also contributed major studies. Particularly important has been the work of the Aeronautics and Space Engineering Board, the Space Science Board, and the Space Applications Board. Each has contributed major studies, either directed at the best ways to use the Station, or on such questions as the readiness of technology for use in Station design.

Fiscal Year 1987 is a year of transition for the work of such advisory committees, as the program shifts from the definition phase into the development phase. Although the problems we face are now somewhat different in the actual design and fabrication period, we continue to depend on the help we get from our advisors, and will do so during the next several years before the first operations commence on orbit.

The NASA Advisory Council is about to organize a standing committee for the Space Station. This committee will look across the full range of matters pertaining to the Station, from uses to technical problems of design and construction and on to the interaction of Station operations with the transportation system. We expect to have subcommittees working with this standing committee to consider various uses of the Station, including a subcommittee charged with examining a key technical problems. The Congress has requested that the NASA Advisory Council examine how we should ensure early scientific return from the Station and how we should plan to operate the complex. My understanding is that Daniel Fink, the Council's chairman, has agreed to this request.

We will shortly participate in a workshop conducted by the Commission on Engineering and Technical Systems of the National Research Council specifically convened to consider how best the NRC can address the numerous questions that will be raised in the Station program as we build and get ready to operate. We will, of course, expect the NRC committees and boards to continue their traditional help to the program office at NASA on matters of program content and strategy.

## CONCLUSION

The FY 1988 budget provides the next rung of the ladder in our climb to a permanently manned presence in space. The Space Station program, identified as a key 1988 Research and Development initiative in President Reagan's recent competitiveness initiative, is a principle vehicle to promote U.S. competitiveness in the development of technology and the conduct of science. NASA, the science community, industry, as

# OFFICE OF SPACE STATION
# FY 1988 BUDGET REQUEST
# TOTAL PROGRAM
## (Real Year Dollars in Millions)

| | FY 1986 ACTUAL | FY 1987 AMENDED BUDGET | FY 1987 CURRENT ESTIMATE | FY 1988 BUDGET ESTIMATE |
|---|---|---|---|---|
| DEFINITION | 190.3 | 250.0 | 250.0 | -- |
| Utilization | (10.6) | (15.0) | (15.0) | -- |
| Advanced Development | (60.3) | (73.0) | (70.0) | -- |
| Program Management/Integration | (55.3) | (88.0) | (93.3) | -- |
| Operational Readiness | (5.2) | (17.0) | (17.0) | -- |
| System Definition | (58.9) | (57.0) | (54.7) | -- |
| DEVELOPMENT | -- | 150.0 | 150.0 | 733.0 |
| Pressurized Modules | -- | -- | (40.0) | (196.5) |
| Assembly Hardware/Subsystems | -- | -- | (27.0) | (204.0) |
| Platforms and Servicing | | -- | (6.0) | (59.0) |
| Power System | | -- | (19.0) | (88.0) |
| Operations Capability/Utilization | | -- | (13.0) | (52.0) |
| Management and Integration | | -- | (45.0) | (133.5) |
| FLIGHT TELEROBOTIC SERVICER | 10.0 | 10.0 | 20.0 | 22.0 |
| OPERATIONS | -- | -- | -- | 7.0 |
| TRANSITION DEFINITION | -- | -- | -- | 5.0 |
| TOTAL | 200.3 | 410.0 | 420.0 | 767.0 |

OSS-4215
2/24/87

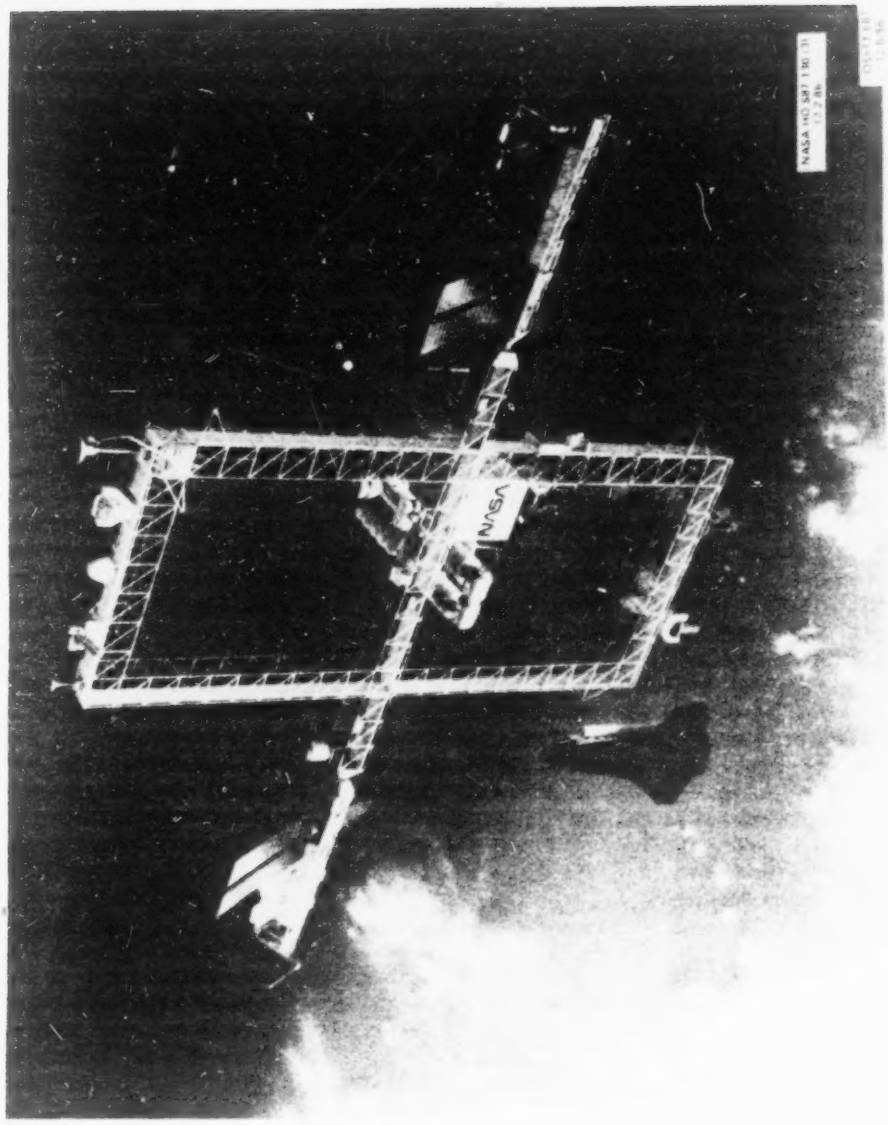
SPACE STATION PRESENTATION TO THE

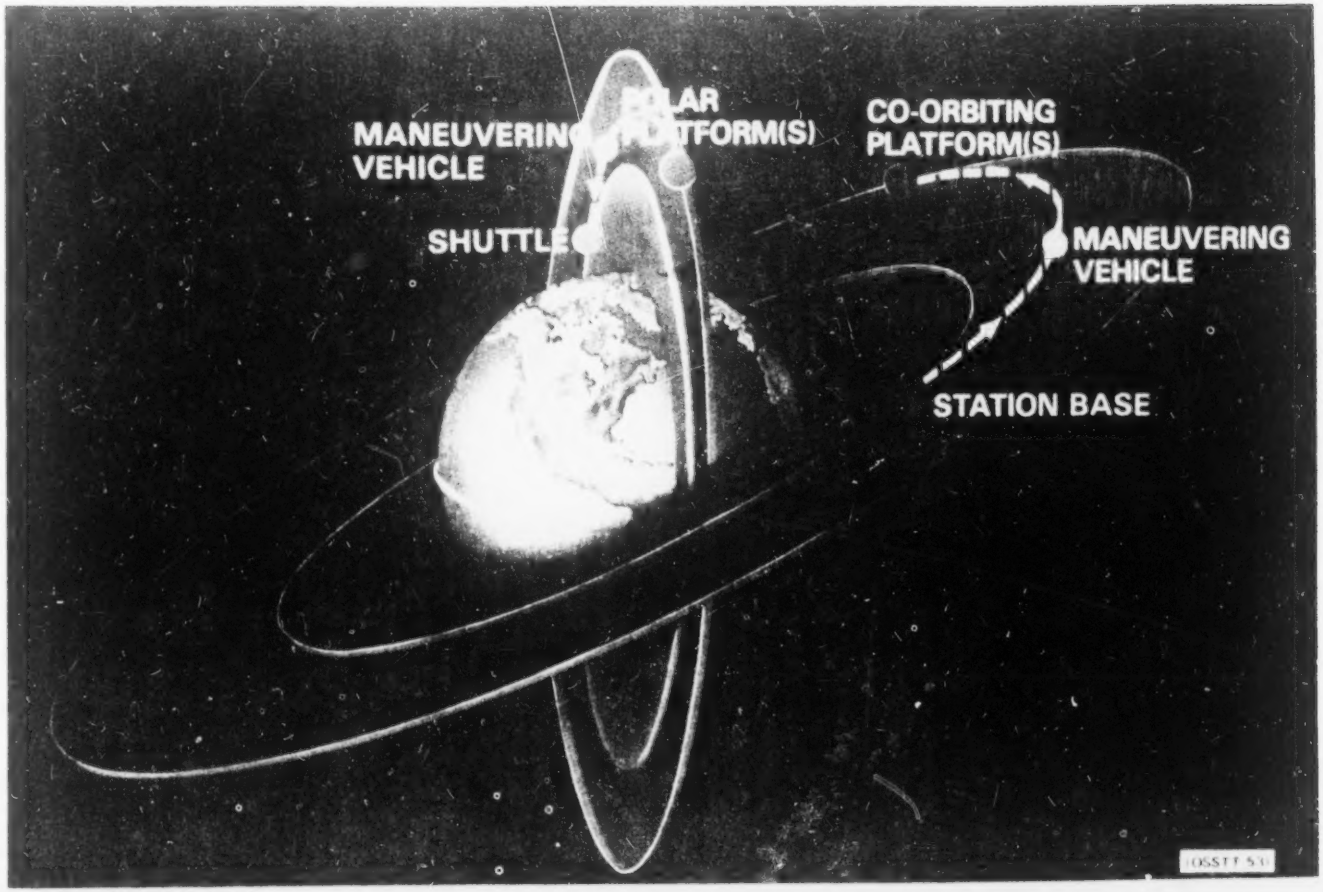
# SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

256

**ANDREW J. STOFAN**
**Associate Administrator**
**for Space Station**

**February 25, 1987**


NASA

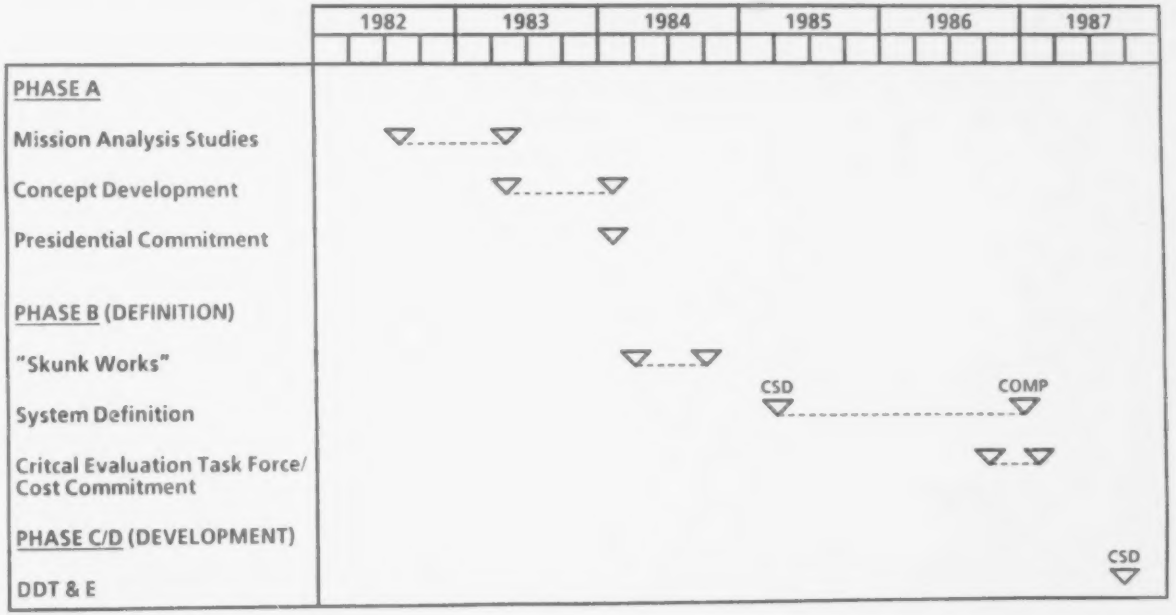

MANEUVERING
VEHICLE
CO-ORBITING
PLATFORM(S)
MANEUVERING
VEHICLE
STATION BASE

# SPACE STATION INFRASTRUCTURE

| WORK PACKAGE CONTRACTS | SPACE STATION SUPPORT | OTHER SUPPORT |
|---|---|---|
| • Manned base | • Program support contract | • STS and STS launches |
| • Platforms | • Test beds | • Orbital Maneuvering Vehicle (OMV) |
| • Initial spares | • Integration facilities | • Tracking and data relay |
| | • Launch processing | • Data processing (experiment) |
| | • Launch processing facilities | • Ground data distribution |
| | • Space Station control center(s) | • Payload operations control centers |
| | • Operations capability development | • International control centers |
| | • Development center technical oversight | • Experiments |
| | • Technical & Management Information System (TMIS) | • Experiment control and data analysis |
| | • Software Support Environment (SSE) | |

OSSTT-308
2/13/87

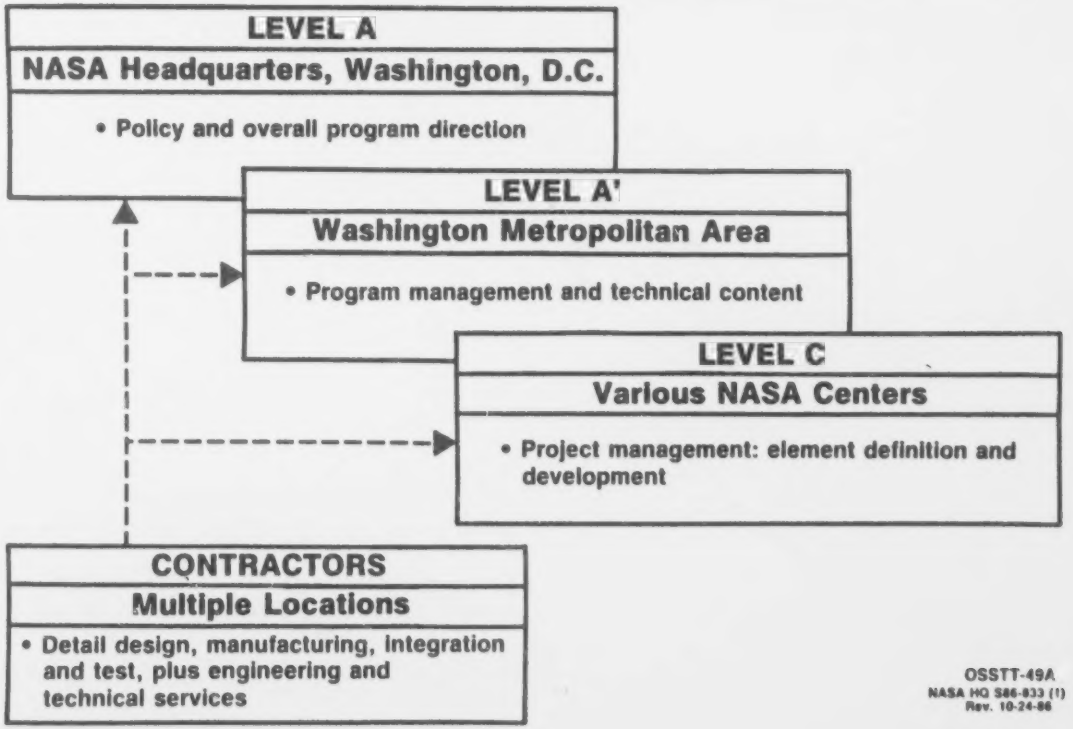
# SPACE STATION PROGRAM
# PROGRESS TO DATE




CSD = Contract Start Date

OSS-4099
2/12/87

# PROGRAM MANAGEMENT APPROACH


LEVEL A
NASA Headquarters, Washington, D.C.
• Policy and overall program direction
LEVEL A'
Washington Metropolitan Area
• Program management and technical content
LEVEL C
Various NASA Centers
• Project management: element definition and development
CONTRACTORS
Multiple Locations
• Detail design, manufacturing, integration and test, plus engineering and technical services

OSSTT-49A
NASA HQ S86-833 (1)
Rev. 10-24-86

NASA Space Station

# SPACE STATION PROGRAM OBJECTIVES

- Develop a permanently manned Space Station by the mid 1990's
- Provide useful and affordable capabilities
- Enhance space science and applications
- Secure international cooperation

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- Design for evolution
- Push automation and robotics technologies
- Incorporate potential for man-tended concept in baseline program
- Blend manned and unmanned systems and capabilities



FILE NAME: S:\SSPrObj

OSSTT-888
NASA HQ S 2-6-87

# RESEARCH OPPORTUNITIES: PRESSURIZED MODULES

## LIFE SCIENCES

- Benefits from low gravity, long duration, and human presence
  - -- Enables studies of the fundamental behavior of living cells (can be applied on Earth to treatment/prevention of cellular disorders in humans)
  - -- Enables new characterization of human as a system (permits development of countermeasures for operation in high-stress situations)
  - -- Enhances understanding of key physiological effects that can be applied to better the human condition (e.g., calcium loss understanding may lead to prevention of osteoporosis)
  - -- Permits U.S. to flight qualify humans for prolonged stays in space (essential if U.S. to compete with other nations in human exploitation of space)

OSS-4105
2/12/87

# RESEARCH OPPORTUNITIES: PRESSURIZED MODULES

## MATERIALS RESEARCH

- Benefits from low gravity, high power, and long-duration
  - -- Fabricate large (~ cm size) defect-free crystals of gallium arsenide for super computers ("macro chips")
  - -- Produce large pure biological crystals essential to identification of basic molecular structure (disease identification and treatment, e.g., arthritis, diabetes)
  - -- Produce pure crystals for use in scientific and defense-related array detectors (e.g., Mercury Cadmium Telluride)
  - -- Characterization and pilot production of lightweight super alloys (immiscible metals)

OSS-4104
2/12/87

# RESEARCH OPPORTUNITIES: ATTACHED PAYLOADS

- **Benefits from human presence, servicing, long duration stability**

**ASTROPHYSICS/PLANETARY/SOLAR TERRESTRIAL**

-- Upper boom ideal location for telescope to search for other planetary systems (data essential to understanding the origin of the solar system and will have profound and irreversible effect on mankind's perception of his place in the cosmos)

-- Upper boom excellent location to conduct long-term high resolution studies of solar surface and solar radiation (understanding long-term solar behavior is major factor in accurate prediction of Earth's weather and climate)

**EARTH SCIENCES**

-- Lower boom and Space Station orbit offer excellent location to monitor tropical rainfall, a dominant factor in controlling the Earth's hydrological cycle (key to predicting draughts and agricultural problems)

OSS-4106
2/11/87

# RESEARCH OPPORTUNITIES: SPACE STATION PLATFORMS

## CO-ORBITING PLATFORM

- Used by Astrophysics for implementation of "Great Observatories" to study the high energy (X-ray) and low energy (infrared) behavior of the universe (these observations may permit forging link between the behavior of fundamental building blocks of matter and the large-scale evolution of the Universe)

## POLAR PLATFORM

- Permits synergistic studies of Earth's atmosphere, land masses, and oceans to enable understanding of the Earth as a system and will enable detailed mapping of Earth resources
- Intergovernmental (NOAA) scientific and observational payload
- International (ESA) complementary platform

OSS-4107
2/11/87

# THE SPACE STATION

## FOR SCIENCE AND TECHNOLOGY

- A research laboratory in space that is permanently manned

## FOR SPACE EXPLORATION

- A point of departure, an enabling capability for future missions

## FOR NASA

- A means in the future for the conduct of business

## FOR THE UNITED STATES

- An essential element of civil space policy
- A symbol of our commitment to leadership in space

## FOR MANKIND

- A first step towards living and working beyond the Earth

**SPACE STATION: A KEY TO THE FUTURE**



FILE NAME: S/SpacSt

OSSTT 39G
NASA HQ S 2-5-87

Responses to written questions submitted by Chrm. Nelson resulting from the February 25, 1987, hearing.

QUESTION 1:

What portion of the 1988 work could be deferred if funding were decreased?

ANSWER 1:

Any FY 1988 reduction will impact the schedule. However, the portion of FY 1988 work that could be deferred would first depend on the size of the reduction imposed and second the status of the ongoing work that would have been started in anticipation of certain funding levels. With the currently unknown nature of these major program variables--cost, schedule, and content--it would be premature at this time to speculate on an impact of a possible reduction in the FY 1988 funding.

QUESTION 2:

Please outline all significant requests for proposals you intend to release in 1986, 1987, and 1988 and include the anticipated release date, and award date.

ANSWER 2:

The significant request for proposals that the Space Station Program has or will issue are as follows:

| REQUEST FOR PROPOSAL | RFP RELEASE | AWARD DATE |
|---|---|---|
| Definition and Preliminary Design | 21 Month Studies January 1987 | Completed |
| Program Support Contractor | February 1987 | July 1987 |
| Detailed Design and Development | March 1, 1987 | December 1987 |
| Technical and Management Information System | July 1986 | Completed |
| Software Support Environment | September 1986 | July 1987 |
| Flight Telerobotic Servicer | April 1987 | Oct-Dec 1987 |

QUESTION 3:

Please explain, in light of the testimony on new cost estimates precisely what was meant by the "design to cost" approach NASA has utilized in Phase B.

ANSWER 3:

A design-to-cost program is generally considered to be one of the first phases of a comprehensive approach to cost management, and as

such, is usually implemented during the development phase (Phase C/D). Since its direct effects occur early in the program when costs are low, design-to-cost by itself is not an effective form of cost management. However, in concert with the successful implementation of other elements of a comprehensive cost management system, the effects of design-to-cost can be exerted throughout the entire lifetime of the program.

One part of the design-to-cost process involves the systematic examination of the primary functional capabilities inherent in a given design. This examination determines the mix of these functional capabilities which represents the greatest performance for a given cost. This process was utilized during Phase B to assist in selecting the basic design and configuration of the Space Station. Although the design-to-cost process was applied primarily to flight hardware, the designs of the ground-based hardware and systems, which are dependent to a large extent upon the final design of the flight hardware, were also assessed. A number of relationships were examined, e.g., development versus change to operating costs; and costs versus the degree of capture of user's requirements. In several instances, analyses showed that a truly significant reduction in operating costs could be achieved at the expense of a moderate increase in development costs. The current program reflects a number of decisions directed toward this end. As the design of the flight hardware matures, the design requirements of the ground-based hardware and systems will likewise mature, thus bringing them into the design-to-cost process.

For most NASA missions, cost is one of a number of parameters, including schedule and technical performance (risk), which are traded off through the development phase of the project to achieve the best balance. To designate a mission as design-to-cost is to make development cost, including projected long-term operations, the important consideration and let the schedule and risk parameters adjust themselves to the cost.

QUESTION 4:

Has the design to cost approach been used on any other major NASA Programs?

ANSWER 4:

NASA has had three previous projects which could be considered "design to cost," although the terminology was different. All of the programs were managed, successfully, to assure that costs were met.

The original Solar Maximum Mission was initially estimated at $75-90 million development cost. During the development, the mission was descoped to remove a major instrument for schedule purposes. Final cost of that development was approximately $77 million.

The SEASAT development was initially estimated at $65-75 million. The final cost was $76 million.

The Mariner Venus Mercury mission development was initially estimated at $87 million. That estimate was modified early in the project to approximately $100 million. The final development estimate was $102 million.

For most NASA missions, cost is one of a number of parameters, including schedule and technical performance (risk), which are traded off through the development phase of the project to achieve the best balance.

QUESTION 5:

What will be the annual operating cost of the Space Station? Please provide a breakout of component costs.

ANSWER 5:

The Space Station Program has established an operations task force to develop detailed operational concepts which will allow us to refine our current preliminary estimates of Space Station operating costs. We currently envision the annual operating costs for the Space Station to be in the $800 million to $1.1 billion dollar range (FY 1984 dollars) and exclusive of launch and similar services provided by other NASA organizations. This range consists of the following:

| Category | Cost (FY 1984 $M) |
|---|---|
| Ground and Space Operations | 230 - 330 |
| Launch Site Operations | 60 - 80 |
| Sustaining Engineering | 240 - 320 |
| Logistics | 130 - 190 |
| Integration and Management | 140 - 180 |

QUESTION 6:

If the operations costs were cut by, for example, 25 percent, how would this affect the development cost?

ANSWER 6:

A mandated reduction in operating costs would indicate either a corresponding reduction in the performance capabilities of the Space Station, or, if performance was to be maintained, a significant increase in the cost of space-based or ground support systems development. These additional costs would be required to provide very robust, autonomous systems which would require minimum servicing or ground control. We are attempting to achieve a balance between performance, supportability, and cost for the design of the Station. This design capitalizes on the state of the art without accepting unnecessary risks.

If one assumes that the full performance of the Space Station is to be maintained, it is probably not possible to achieve as large a reduction as 25% and still assure safe operation of the Space Station. Launch Site Operations will always be complex. Crew training must be extensive. The spares and logistics effort will be large and cannot be easily reduced. There is a substantial engineering effort required to assure that we understand and can respond to the in-flight anomalies that will-inevitably occur. We will need continuing operations planning and user integration, etc. One way operation costs could be reduced would be to attempt higher levels of automation to reduce the staffing of the control centers or to build the hardware to extremely long lifetime specifications in hopes of reducing spares requirements. These two elements are not a significant a portion of total operation costs and the savings in the best case would probably be only a few percent. The cost of these developments is hard to predict accurately because of the technology advances required, but they could be substantial.

NASA is well aware of the inefficiency that can result from reducing development cost at the expense of operations complexity and cost. We have made several increases to the development budget, such as closing the Environmental Control and Life Support System and moving to a hydrogen/oxygen propulsion system to decrease operations costs. We have also undertaken a very substantial effort by the Operations Task Force to assure that the operations approach is the most cost effective consistent with program safety. We believe we have achieved a balance between development and operations costs and, therefore, any arbitrary reduction in operation cost could disproportionately increase development cost or unacceptably compromise crew safety.

QUESTION 7:

The ATAC report of September 26 states that, although Congress has provided funding to ensure a national initiative in robotics, no similar incentive exists for automation.

Please state the funding identified for each of these two areas for FY 1988 and the projected funding over the next five years.

ANSWER 7:

The funding for the Flight Telerobotic Servicer (FTS), an element of the Space Station, is projected to be $22 million in FY 1988. The Space Station budget for advanced automation of cognitive tasks is not known at this time. The budget will depend on: (1) the proposals submitted in response to the Phase C/D RFP's; (2) on the results of the contract negotiations; and, (3) the extent to which it is deemed necessary to establish a specific advanced automation initiative. The Office of Aeronautics and Space Technology plans to obligate approximately $12M for generic telerobotic technology and $14 million for generic automation of cognitive tasks in FY 1988.

QUESTION 8:

When will NASA approve an automation and robotics plan which identifies validated functional and system performance requirements specific enough for design and development of an information system architecture?

ANSWER 8:

The Program Support Contractor is required to prepare an Automation and Robotics (A&R) plan which is updated quarterly. It is expected that the submittal, scheduled approximately for the second quarter FY 1988, together with other system integration documentation, will contain sufficient detail to finalize the information system architecture.

QUESTION 9:

According to NASA's draft RFP's, ATAC guidance and direction is not binding on the contractors who are developing the detailed plan for automation and robotics. How will NASA utilize ATAC work in directing the contractors?

ANSWER 9:

The ATAC recommendations are reviewed systematically at Levels A and A' within the Space Station Program Office. The Administrator's letter of transmittal to Congress contains a summary of this review and of the actions planned in response to the ATAC recommendations. Given that the ATAC activity represents a continuing process, we expect to continue our established process for review and action. When appropriate, this process will include actions required of the contractors.

QUESTION 10:

To what extent will an automation baseline be established in the initial Space Station? How will this be extendable to expert systems and automation of Station-based operating functions to reduce ground support needs?

ANSWER 10:

The automation and robotics (A&R) plan to be developed by the Program Support Contractor will contain a baseline implementation for A&R. This will largely consist of applications of expert system technology (for planning, trend analysis, diagnostics) both on-board and on the ground. This capability can increase the availability of the crew for productive activities and decrease the requirement of staff on the ground.

QUESTION 11:

What level of automation (percent of functions) has been baselined for ground control operations? What criteria was used in choosing the functions to be automated?

ANSWER 11:

The Phase B studies have not resulted in an automation and robotics (A&R) plan for the Station, but rather in options for such a plan. A typical option for the A&R plan forecasts a reduction of work-hours devoted to routine maintenance by a factor of 2 or 3, with respect to technology previously used in space. As stated previously, the A&R plan will be produced by the Program Support Contractor in the future.

Several considerations have had influence in selecting the A&R options studied:

- o Initial cost
- o Impact on operations costs
- o Crew productivity
- o Maintainability
- o Power requirements
- o Spin-off for terrestrial applications
- o Growth potential
- o Design risk
- o Safety

QUESTION 12:

In the justification for the Space Station support center you state that 60 to 400 personnel will be needed for ground operations. What level of automation was assumed in making this estimate?

ANSWER 12:

The projected staffing of the Space Station support center at JSC reflects progress made in the capabilities of ground control systems. Tentatively, small staffs will be required for most operations situations with full support only required in unusual circumstances. Since many of these staff members would also be supporting NSTS and other programs, significant economies can be realized. These economies can be realized not only by modern communications and data processing technology, but also by the use of automation in the ground systems. The planned staffing levels reflect conservative judgements. These have been made regarding the effectiveness we can expect from the automation of those systems for which reliable technology exists or can be expected to mature as development proceeds. Our goal is to maximize the use of automation all systems consistent with safety, performance, and cost effectiveness as the Space Station evolves.

QUESTION 13:

How much of the FY 1987 and 1988 funds are intended to go toward the development of the software support environment?

ANSWER 13:

We currently plan to spend approximately $10 million in FY 1987 and $30 million in FY 1988.

QUESTION 14:

When will the software support environment be baselined?

ANSWER 14:

The Software Support Environment (SSE) is baselined and will be delivered in increments. The functional requirements are currently under configuration control. Contract start is currently projected for June 1, 1987. The contractors will provide access to an interim SSE capability at one month after contract start. That interim will not be configuration controlled by NASA. However, it is intended to meet program needs until delivery of the SSE Development Facility (SSEDF) at 15 months after contract start. The SSEDF will be under NASA's configuration management. The SSE will continue to evolve in response to the baselined requirements. Subsequent increments will be delivered to NASA for accepting and baselining in roughly equal intervals starting 28 months after contract start.

QUESTION 15:

How will the contractors know the nature of the software support environment for bidding purposes?

ANSWER 15:

The Software Support Environment (SSE) was defined with industry's help. The program was intentionally very open with plans and evolving requirements up to the time of the SSE RFP release. A library of all associated industry and NASA SSE documentation is available at JSC. SSE contract start is scheduled for July 1987. The prospective development phase bidders will have immediate access to the nature of the SSE at that time.

QUESTION 16:

To what extent will software conversion be necessary on the part of the contractors once the software support environment is baselined?

ANSWER 16:

The first true NASA baselining of the Software Support Environment (SSE) capability in response to requirements already under baseline control will be 15 months after SSE contract start. It is anticipated that some contractor conversion of primarily simulations and models will be necessary at that time. However, such conversions should not be very extensive. The program will still be conducting requirements and preliminary design activities leading to the preliminary design review. (In other words, no detailed design or actual code development should have taken place). However, there will be a conversion of people training from previously provided in-house and commercially available software capability to that provided by the SSE. Such a transition is a necessary step to achieve the needed uniformity in software approach that in turn will enable successful integration and cost-effective maintenance downstream.

QUESTION 17:

When will the Software Support Environment produce the tools required for expert systems development?

ANSWER 17:

Those tools (to the extent they are different from that used to develop any other software) are expected to be provided by the Software Support Environment (SSE) in response to specific requirements which would best be satisfied by the development of expert systems. To date, the requirements unique to expert systems have been identified. Since the SSE is an evolutionary capability, unique expert systems tools will be added to the SSE tools inventory in downstream delivery increments.

QUESTION 18:

What measures are being taken to ensure that TMIS accurately and comprehensively captures Space Station design knowledge necessary for the follow-on evolutionary development of expert systems and other automation and robotics?

ANSWER 18:

The Space Station Technical and Management Information System (TMIS) serves as the facilitating and controlling mechanism for the implementation of the program capability. This allows for shared program-wide configuration management, scheduling, computer-aided design, computer-aided engineering, archiving, data base management system, network communications, and other essential program functionality. The design and functionality of TMIS is driven by established program requirements; TMIS is the facilitator of such requirements to the program. The responsible participants in Levels A, A', and C insure the implementation of the requisite databases, perform analyses, and utilize other TMIS based functionality as may be required to achieve the Station goals and objectives.

Key to this program-wide information environment is the TMIS implementation of the Information Resources Management policies as mandated in OMB Circular A-130. This implementation provides for the consistent, comprehensive, and efficient management of program information. Specifically with regard to design knowledge capture (DKC), TMIS has taken an active role in soliciting appropriate program requirements; a TMIS sponsored electronic mail mailing list of key Agency DKC personnel was established to facilitate communication of the DKC community with TMIS personnel, and numerous discussions have been held between TMIS personnel and DKC experts at JSC, ARC, LaRC, and other NASA sites. Clearly, TMIS is already destined to capture much of the design knowledge available within the program. TMIS will continue to capture and retain all information per its direction from the program. Since DKC is an emerging technology, capabilities and implementation insights are still evolving. As the programmatic DKC requirements are identified and refined by NASA and other program experts, TMIS will seek to facilitate such requirements as full as practical, and provide that functionality to the appropriate program participants.

QUESTION 19:

What is the range and extent of TMIS (How many centers and how many contractors are to be provided TMIS assets and services? How will integration be accomplished among these many parties and across the many functions incorporated by TMIS?)

ANSWER 19:

The necessary capabilities for TMIS are specified in the TMIS Functional Requirements Document. This configuration controlled document resulted from interviews with about 600 NASA personnel across the program. This document served as a basis for the current major procurement activity for selection of the TMIS System Integration Contractor (SIC) and the design and implementation of the initial operating capability (IOC). This original requirements analysis determined that TMIS had to provide (1) program-wide integration of information and processes; and (2) appropriate TMIS interfaces to all program participants. Accordingly, TMIS will be implemented in eleven NASA organizations: Headquarters, Level A', MSFC, JSC, GSFC, LeRC, KSC, LaRC, ARC, JPL, and NSTL.

TMIS will provide integration of hardware, software, networking, data administration, and appropriate support to implement the requisite processes and information management at Levels A, A', and C. Via interface specifications and other documentation, other program participants may implement interfaces to TMIS. There is no intent to directly provide TMIS hardware assets or services to any contractors. However, the contractors will have the ability to access TMIS.

Within NASA, TMIS will be interfaced to or integrated with existing resources (e.g., networks, institutional analytic tools, etc.), wherever appropriate. The original interview process identified the information flows expected to be in use across the program. This interview process is currently being revisited at every NASA center. Additionally, the various aspects of the Administration Information Resource Management policies are being utilized to assist in developing the program-wide information strategies and strategic information plan. As TMIS evolves, it is recognized that more and more of the processes and data environments must become fully integrated with one another. This increasing integration is integral to the planning of future TMIS increments.

QUESTION 20:

The TMIS project is designed to initially use off-the-shelf software written in COBOL and FORTRAN, which will eventually be converted to ADA as ADA off-the-shelf software becomes available. How will life cycle costs of the system be affected by this approach?

ANSWER 20:

The approach stated above for management of the TMIS life cycle is inaccurate. The established intent is to fully utilize commercially available off-the-shelf software. There has never been an intent for TMIS to acquire the responsibilities for source code development or maintenance of such commercial packages. Historically, new, more

effective software capabilities become available within a few years after their initial introduction. TMIS seeks to take advantage of this evolving commercial market.

Evolution from one product to another product within the various phased implementations of TMIS is triggered by life cycle cost-benefit analyses. TMIS seeks to minimize the development of software. However, in order to integrate many TMIS capabilities, some limited interfacing is necessary. To achieve this interfacing, TMIS proposes the extensive use of standards and the use of appropriate languages. Since the TMIS project is currently in a proposal evaluation phase, it is not appropriate to discuss the effort other than as a software development effort.

It is recognized by TMIS that the Space Station Software Support Environment (SSE) is currently not available and will not be operational until the proposed interfacing development for TMIS has been accomplished.

Regardless, the TMIS approach is to implement any necessary developments in the most cost effective manner. While it is likely that SSE will be used by TMIS in the future, no approach is "a priori" either precluded or mandated. The TMIS life cycle itself has been fully discussed in the TMIS Request for Proposals (RFP's) and other TMIS documentation. It is fully in accord with the life cycle approach of the NASA Software Management and Assurance Program. The cyclic nature of the TMIS implementation process within the life cycle is intended to continue to provide the program with the most cost effective system to meet evolving program needs and to remain current with commercially available capabilities.

QUESTION 21:

Please outline the projected TMIS costs and milestones over the next five years.

ANSWER 21:

The incremental phasing and the extent of TMIS functionality are designed to respond to the evolving needs of the Space Station program as it proceeds from contract start through design and development and progresses towards the Space Station operational phase. The milestones identified in the RFP were:

| | | |
|---|---|---|
| IOC' | April 1987 - December 1987 | early preliminary design |
| IOC-1 | December 1987 - mid 1988 | early detailed design |
| IOC-2 | mid 1988 - mid 1989 | late detailed design |
| IOC-3 | mid 1989 - late 1990 | integration and checkout |
| IOC-4 | late 1990 - late 1992 | flight verification |
| IOC-5 | late 1992 - late 1194 | operations |
| evolution | late 1994 | |

These phases will be adjusted when the Space Station program milestones are identified.

Funding for IOC' and definition and design of IOC-1 totaling approximately $40 million has been included in the FY 1987 and FY 1988 NASA budget requests. The estimated life cycle cost of IOC',

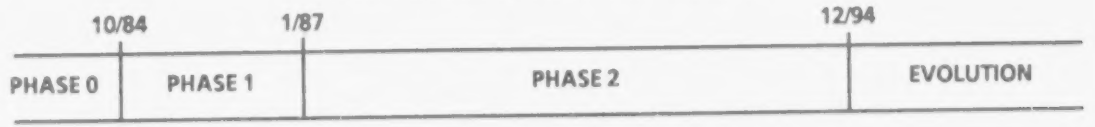
TMIS PROJECT DIVISION

SPACE STATION PROGRAM OFFICE

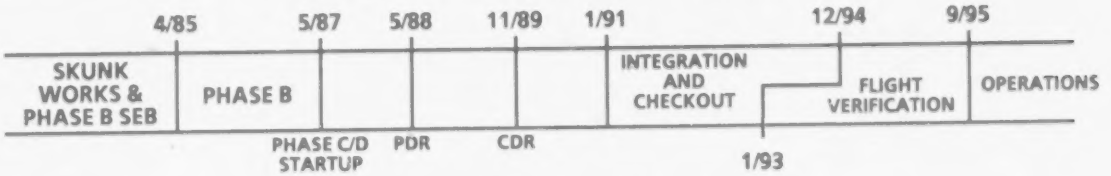
# INITIAL TMIS SCHEDULES

NASA

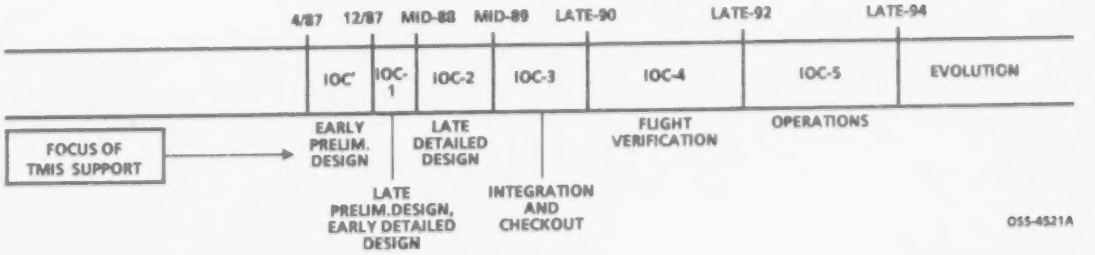
## TMIS IMPLEMENTATION PHASES




## SPACE STATION PROGRAM PHASES




## INTEGRATED TMIS/SSP PHASES



TMIS PROJECT DIVISION

SPACE STATION PROGRAM OFFICE

# TMIS BUDGET 483-8

## Values in $M (84)

NASA

| | DEFINITION | | | | NON-PRIME DEVELOPMENT | | | | | | OPER. READINESS | | REC. OPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 | FY 92 | FY93 | FY 94 | FY 95 | FY 96 |
| PHASE 0 | 0.9 | 0.9 | | | | | | | | | | | |
| PHASE 1 | | 9.2 | 9.1 | 2.4 | | | | | | | | | |
| PHASE 1A | | | | 3.9 | 2.2 | | | | | | | | |
| PHASE 2 | | 1.2 | 3.9 | 23.8 | 36.2 | 35.9 | 36.8 | 30.6 | 28.0 | 26.5 | 25.7 | 23.8 | 23.8 |
| TOTALS | 0.9 | 11.3 | 13.0 | 30.1 | 38.4 | 35.9 | 36.8 | 30.6 | 28.0 | 26.5 | 25.7 | 23.8 | 23.8 |

NON-PRIME DEVELOPMENT COSTS 196.2

TOTAL TMIS COST THROUGH FY 96 325.0

OSS-4531
3/16/87

which includes the previously identified $40 million, over the eight year life of the contract is approximately $80 million. Future requests will include funding for subsequent TMIS increments as future TMIS requirements to support the Space Station program are identified.

QUESTION 22:

If the scope of TMIS were narrowed to eliminate management information requirements, what would be the impact of the TMIS costs?

ANSWER 22:

TMIS is intended to provide an integrated system to facilitate the technical and management information processes of the Space Station program. The attached chart from the Functional Requirements Document illustrates a matrix of the necessary Space Station program processes facilitated by TMIS tools and capabilities. It is not possible to separate a management requirements implementation without impacting some critical aspects of the technical requirements implementation. It is true that some specific tool, such as the scheduling or the spreadsheet system, could be removed from the integrated system being provided by TMIS, but then the capability to operate various technical process would also be compromised.

TMIS is providing common tools to support all such areas of the Program. It integrates all processes and their associated information environments so as to implement a time-phased capability necessary and sufficient to achieve the Space Station program. A broad-ranging, multi-disciplinary approach is essential for the Space Station Program. An engineering or technical function cannot be considered to exist in isolation, but needs support from and extends support to other program functions. TMIS tools and implementation philosophies address this integral "whole-man" concept. Fragmentation of the necessary program capabilities clearly results in a decrease in overall productivity. Whether the capabilities are provided by TMIS or are provided elsewhere within the program, the necessary processes to implement a Space Station remain the same. However, through the TMIS integration of capabilities and implementation of a comprehensive information strategy, program costs and schedule risks are minimized.

QUESTION 23:

To what extent will technical data be exchanged with foreign participants?

ANSWER 23:

TMIS facilitates program information control and interchange. The analysis of information flows and process descriptions provide insights as to what information is needed by whom and when within the program life cycle. Our international partners and other international participants will be allowed appropriate access to the information required to accomplish their portions of the program. specifically, the information which is required to identify the

TMIS PROJECT DIVISION

SPACE STATION PROGRAM OFFICE

# TMIS PROCESS/CAPABILITIES MATRIX

NASA

| CAPABILITIES/TOOLS \ SSP PROCESSES | 1. Design | 2. Technical Analysis | 3. Design Review | 4. Requirements Analysis | 5. Configuration Management | 6. Documentation | 7. Interface Control | 8. Planning | 9. Maintenance | 10. Policy Development | 11. Technical Contract Management | 12. Schedule/Project Management | 13 Budgeting | 14. Integration | 15. Cost/Financial Analysis | 16. International Relations | 17. Training | 18. Administration | 19. Admin. Contract Management | 20. Performance Management | 21. Operations | 22. Prototyping | 23. Program Review | 24. Acquisition | 25. Public Relations | 26. Test & Verification | 27. Inventory Management | 28. Customer Relations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAD | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CAE | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Common User Interface | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| DBMS | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Remote System Access | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| File Transfer | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Image Processing | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Cost/Price Modeling | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Word Processing | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Graphics | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Electronic Mail | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Teleconferencing | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Spreadsheets | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Project Management System | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Scheduling | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Computer Aided Instruction | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

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appropriate interfaces and achieve program integration. The exact nature and extent of that information will be determined by the established Memorandum of Understanding with the international partners, and other appropriate mechanisms.

It is currently envisioned that no security classified information and relatively little proprietary information will be incorporated in the TMIS environment. The TMIS system provides security mechanisms to insure the protection of any such information which may be incorporated within TMIS.

QUESTION 24:

How will free access to TMIS be promoted without compromising breaches of proprietary information and unauthorized technology transfer?

ANSWER 24:

TMIS does not provide "free access" to information. Sufficient internal security mechanisms are provided to protect all TMIS information from unauthorized disclosure. To enhance productivity and encourage utilization of TMIS, it is recognized that the user should not be burdened with the undue navigation of layers of security protections.

Currently, three levels of security are planned to be incorporated over the time-phased life of TMIS. Access control over these levels are implemented at the (1) operating system level; (2) the file/process level; and, (3) the data record/item level. At a minimum, a valid user name and corresponding password are required to access any TMIS capability. Internal data encryption will be available when required. The NASA-wide program support communications network provides encryption of all information flowing over that element of the TMIS system. The explicit permissions to read/write/modify information is enabled by the various data base administrators working in concert with the data administrators and appropriate Space Station control boards. The data base and/or data administrators may also require the user to navigate additional levels of security, each requiring user passwords and other access control techniques. Additionally, the TMIS system integration contractor (SIC) provides network analysis, system journaling, and other services so as to identify, isolate, and eliminate any attempted hostile break-in to the TMIS system.

Access to specific information is granted to those with a need to know. This is facilitated by the established Space Station control board mechanisms. For example, of the information developed by Work Package 1, only the information baselined by the Work Package 1 configuration control board is expected to be available to most users at other work package centers. Information relating to ongoing internal Work Package 1 trade studies would be expected to be restricted to those with a need to know. This normally lies within the specific work package and access may be regulated by a lower control board authority. This type of information may be retained within TMIS as private to as few as one or two users. Thus, a hierarchy of data access is envisioned. As the information is pedigreed, the configuration control and program visibility increases.

QUESTION 25:

When will NASA make a decision concerning a Crew Escape Return Vehicle (CERV)?

ANSWER 25:

NASA expects to make a program decision concerning the requirements for a CERV during the first quarter of calendar year 1988. Funding could be requested as early as FY 1989. This timing corresponds with the completion of a Phase B study of the CERV which will complete the definition and preliminary design of a CERV. This schedule is compatible with the Space Station schedule. CERV might also provide capability for cargo return as well as the return of the crew.

QUESTION 26:

Why wasn't the CERV baselined in Phase B?

ANSWER 26:

Phase B, the definition phase, was underway prior to the Challenger accident. At that time, the concept of "safe-haven" was developed, wherein on-orbit emergencies would be accommodated within the manned base complex and provide for crew safety. However, the consequences of 51-L and the potential for a failed NSTS were incorporated late in the Phase B effort and have resulted in early studies on a CERV.

QUESTION 27:

Under what conditions could a CERV be useful?

ANSWER 27:

The CERV might be useful under the following conditions:

1. Failure of the NSTS - Crew cannot be returned in a reasonable length of time.

2. Crew Failure - Emergency medical situation, requiring hospitalization.

3. Failure of the Space Station - Generic failure, catastrophic failure.

QUESTION 28:

What plans does the Space Station office have for utilizing probability risk analysis to address critical safety systems?

ANSWER 28:

The Space Station envisions an active program of Probabilistic Risk Analysis (PRA) to augment the technical understanding of critical safety issues/options, where appropriate. Several points are mentioned in passing: (1) PRA will not be utilized as a substitute

for an in-depth technical understanding of design/operational issues, (2) Space Station is sensitive to the limitations and/or inadequacies of the "failure rate" databases upon which PRA is predicated, (3) there continues to be large uncertainties in the numerical bottom-line results of PRA's, (4) PRA can be quite useful in identifying and examining the underlying assumptions (i.e., success criteria, time dependencies, etc.) and parametric sensitivities in systems analysis, and (5) as development, qualification, and on-orbit experience results become available, the database can be expanded to validate the PRA.

QUESTION 29:

What assurance can you give us that there will be a robust life sciences program on the Space Station?

ANSWER 29:

The Space Station design has been driven by user requirements from its very beginning. As such, the Station will have the capability to support a robust life sciences program. The Space Station's microgravity environment and extended time on-orbit will enable scientists to make significant discoveries in the life sciences field.

The Space Station Requests for Proposals (RFP's), which have been sent to industry are calling for accommodation of those life sciences activities which have been identified by the Office of Space Science and Applications (OSSA). OSSA is responsible for conducting the Life Sciences Program and will decide, in accordance with their selection procedures, the extent of the experimental program.

QUESTION 30:

What will be the proportion of life science to material science?

ANSWER 30:

It is too early in the program to specify the exact array of scientific experiments to be conducted aboard the Space Station. Station development will support both life sciences and material sciences. NASA's Office of Space Science and Applications will identify Space Station experiments and the priority they warrant.

QUESTION 31a:

How much would it add to the cost of the Station for a small animal holding and research module, which would include a 4-meter centrifuge?

ANSWER 31a:

We have not costed out such a module since this facility is not part of the Space Station baseline configuration. However, since we recognize the potential need for such a capability at some time in the future, we have included a request for the pricing of elements

necessary to accommodate those life science requirements identified in the mission requirements database and not met in the baseline. This pricing request is in the RFP which will be sent to our Work Package 1 contractors.

QUESTION 31b:

How can you "scar" for such an addition, as a growth element, if it is not in the baseline?

ANSWER 31b:

Our conceptual studies of Space Station growth configurations have included analysis of accommodations for a 4-meter centrifuge. In the growth concept the centrifuge is located in a short module, referred to as a "pocket module," attached to a node or at the end of the life sciences module. The baseline Space Station module arrangement provides space and attachments ports for the addition of modules such as the "pocket module." The design includes "scarring" for the addition of utilities, such as water, cooling and heat, if required for the operation of the centrifuge.

QUESTION 32:

When do you plan to start the development of the resource elements for the polar platform?

ANSWER 32:

Pending award of a contract, it is our plan to begin the design of the U.S. polar platform resource elements in the November 1987 timeframe. The initial design will be based on instruments, e.g., the synthetic aperture radar, currently under development by NASA; the operational instruments which NOAA plans to fly; and the conceptual design studies of a full complement of remote sensing instruments, known as the Earth Observing System (EOS). The Space Station Office will begin the development of the platform elements when EOS, which is a high priority new start candidate within Office of Space Science and Applications, is approved.

QUESTION 33:

What will you do in the way of polar platforms if the West Coast Shuttle site does not become available?

ANSWER 33:

We are studying the option of the polar platform launch from the West Coast site on a Titan vehicle. Future servicing is planned to be accomplished using a Shuttle. If it appears that the site will not be available when the first servicing is required, or that the site will never become available, several options will be assessed, e.g., using an expendable launch vehicle (ELV) and an orbital maneuvering vehicle (OMV) to deliver assets to the platform, with a "resident robot" on the platform used to manipulate these assets.

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QUESTION 34:

How could you include on-board robotics in the polar platform baseline to ensure against the contingency of no manned servicing from the West Coast?

ANSWER 34:

A concept has recently beer discussed for a "resident robot" on the polar platform to provide servicing in case manned flights are not available from the West Coast. The "resident robot" could be based on the platform and traverse to the servicing platform locations by either a rail mechanism or an extendable astro mast. We are currently planning to investigate this and other concepts for unmanned servicing of the polar platform.

QUESTION 35:

What do you need to do to the Station configuration if we decide that a manned mission to Mars should be our next major goal in space?

ANSWER 35:

The Space Station could accommodate the assembly, check-out, and other preparations for launch of a manned Mars vehicle with enhancements. Additions to the Space Station infrastructure for any potential manned Mars mission would include a quarantine module for the precursor Mars sample return mission, additional structure to serve as scaffolding for assembly of the Mars vehicle, and accommodations for a space based Orbital Maneuvering Vehicle and Orbital Transfer Vehicle. However, before any manned Mars mission could be conducted, new technologies would have to be developed. A Space Station would be required for these critical technologies. The include: orbital assembly and construction techniques, automation and robotics, techniques for handling and transfer of cryogenic fluids, closed environmental support systems, "variable gravity," and research on the effects of long duration weightlessness.

QUESTION 36:

Since the program support contractor will be doing systems engineering and integration work, can you assure us that you will be able to avoid conflict of interests if the same contractor is providing hardware?

ANSWER 36:

In our planning for the procurement of the program support contractor, the potential conflict of interest between this contractor and one of the hardware contractors was a major consideration. As a result, we took two steps to mitigate this potential conflict. First, we eliminated from the competition for the program support contract (PSC) all offerers planning to bid for the role of prime contractor in any of the work package contracts. Second, the PSC request for proposals asks all PSC offerers to describe in their proposal how they plan to organize to mitigate such conflicts in the case that they are also selected as work package subcontractors. Their response will be evaluated as a part of the PSC selection process.

Mr. NELSON. You stated that there is more than enough justification for the space station, and we certainly agree with you about that. We indeed have in many cases intimate knowledge and have been very vocal in our support of all these research opportunities that you have enumerated here, in life sciences and materials research, and the earth observation, and so forth and so on that you went through.

But that wasn't the question. The question was, why has the cost gone from $8 billion upward to the price that Bob's going to give us—that is the White House—which in current dollars, or in 1988 dollars is probably about $20 billion. So that's the question.

Mr. STOFAN. I can talk in general terms, but not——

Mr. NELSON. Why did it increase?

Mr. STOFAN. My specificity will have to stop, you know, just short of preserving my job.

Mr. NELSON. Well, earlier—and I understand that. We don't want you in any jeopardy and we understand you must be as frustrated as anybody because of the constraints and the shackles put about your ankles. But the question is, which you said you would answer for us, how it grew from $8 billion. How did it?

Mr. STOFAN. I think there are three elements where it has grown. It has grown in the estimates of the basic hardware, and that's the smallest increase. The reason it increased in that arena is that these are estimated by computer modeling of what it takes to build a given piece of hardware. And again, the increase there was due to complexity factors that go into the modeling. That there have been differences of opinion of how complex it is to build a module, how complex to build a truss structure, power system.

And in the long period of discussion over the last several months, six months of looking at the cost turned in by the contractors and the NASA's center's estimate and working with the controller, the estimates went up on complexity factors which raised the cost somewhat in that arena. But of the three areas, that's the smallest increase in cost.

Mr. WALKER. Would we be right to assume, as the White House does, that that figure is $1 billion?

Mr. STOFAN. I can't comment on that.

Mr. WALKER. Well, that's the—I'm giving you the White House figures. Is the White House figure somewhere in the ballpark?

Mr. STOFAN. That's in the ballpark.

Mr. WALKER. All right.

Mr. STOFAN. Okay, the second area of increase on the Space Station has been in that center column which I pointed out on the other viewgraph. And I think at least a couple of billion dollars of the increase in that area was due to the fact that we now are funding the centers and providing a basic support that is necessary for the Space Station in a way that we did not at the time the original estimate was made.

So that's a change in the ground rules, bookkeeping, if you will. It went off of one column of—I don't know if you ever heard the phrase DITMO. It was a support that went to the center for years and years. They changed that now and provide very little of that. Therefore, the individual elements, and the same with Dick Truly is picking up costs now that he did not pick up before and so am I.

So it's a different—NASA changed it from one bookkeeping account to another and it turned out it happened, unfortunately, to fall into my account. Because again, there's only two accounts at some of the centers, the manned centers, JSC.

The other thing was, we have with this program support contractor, doing the systems engineering integration with a contractor was not anticipated at the time. Now the third in that center column, as I mentioned, is that when we looked at this in detail—and let me say, originally what was done is that middle column was estimated with a percent. It was said that looking at the past programs, making an eyeball guess at it without going into detail, it was about 19 percent of the program would cover everything in that center column.

And it turns out that when we went back and looked at what we needed—we went back to each center, went into detail what they wanted, went up to the center director, had the center director come in and sit down with Tom and I for a day and scrub them down and looked at what was really there, the 19 percent figure was grossly in error. And it has in the past been an area that has been the poorest estimates in projects in the past in NASA of trying to understand everything that supports this, and all the nooks and crannies in the center and pulling it all together to make an estimate.

So there's three reasons of why that column went up, and that was the biggest increase in the program.

Mr. WALKER. If I might. It sounds to me like we had the old shell game played on us here, and I'm just trying to figure this out. Are you telling us the $8 billion station that we heard about before included no cost estimate for the infrastructure?

Mr. STOFAN. 19 percent. It was guessed that it would be about 19 percent. It turns out, it's a lot more than 19 percent.

Mr. WALKER. And where did that 19 percent come from?

Mr. STOFAN. Looking at past programs and trying to use the computer models of past programs. When it was looked at, they said, it looks like that infrastructure support is about 19 percent of the program cost. And it was a factor that was coming up from computers.

And I know the people, I have talked to them myself and asked the same question, they were not trying to hide. They just said that looking at past programs, that appears to be about it, and someday we've got to dig down into every one of the centers and find out what's there. And when we did we found out something totally different than we anticipated.

Mr. WALKER. It would be interesting to know what past programs they used. The shuttle program, the add-on cost to the shuttle program are $70 million, but it cost us $250 million to fly the shuttle, which means that that infrastructure in shuttle flights is a massive percentage of the entire cost of flying every shuttle flight.

Now to suggest that this was somehow going to be lower than what it's costing us to fly the shuttle, was to suggest nonsense. And so we were really dealing at that point with a nonsense figure.

Mr. STOFAN. Well, I think we're dealing with a figure that when they didn't look at just the shuttle, they looked at a whole crossrange of programs, manned and unmanned, put them all into the

computer modeling and it said about 19 percent was the correct figure.

Mr. WALKER. But obviously, if you use a lot of unmanned programs you don't have nearly the infrastructure for unmanned programs as you do for manned. The only thing that's really relevant here are manned program costs.

Mr. STOFAN. But remember at that time, in defense of the people who made that estimate, the station was not that well defined and the configuration today is totally different than it was at that time. So this is not a black and white case of people trying to hide something. I really do not think that people were trying to hide——

Mr. WALKER. White House says that infrastructure costs $3.6 billion. Are they in the ballpark?

Mr. STOFAN. That's the ballpark.

Mr. WALKER. I see, all right.

Mr. NAGLE. Could I—would the gentleman yield?

Mr. WALKER. Yes, I'd be glad to yield to the gentleman.

Mr. NAGLE. First of all, my understanding is that you're here today asking for $733 million for the space lab, for development of it, the pursuit of it; is that correct?

Mr. STOFAN. $767 million.

Mr. NAGLE. $767 million, I stand corrected. And you won't tell us or you can't tell us or you've been told not to tell us how much the total thing is going to cost?

Mr. STOFAN. The program, because of the cost increases obviously we had to go back to the OMB and review the program with them, and go back and review the program with the Administration. And so until we get through that review process and come out of that with an agreed program with the Administration, I do not know what cost to give you. Because I am sure there are going to be people who will want to look at alternatives. And if we come up with an alternative, then the number that you're reading is not right.

Mr. NAGLE. Would the gentleman yield further? I thought you said earlier you'd been told not to tell us. Did I misunderstand you?

Mr. STOFAN. We were told the numbers that we have provided to the Administration are, right, they're under review by the Administration and, therefore, not for public consumption. And again, it's not one number. People are looking at the program in a broadest aspect to see if there are other things that can be done, and modifications to what we're doing.

So until I have the program clearly defined and in agreement—Dr. Fletcher and the Administration have an agreement between the two of them of what is the content of this program, until that I cannot tell you what the program is going to cost.

Mr. NAGLE. Just two simple questions. Number one, who told you not to tell us?

Mr. STOFAN. I can't tell you what the cost of the program is because we haven't agreed with the Administration on the content at this time.

Mr. NAGLE. I don't think that was the question I asked. I said, who told you not to tell us?

Mr. NELSON. His boss did.

Mr. STOFAN. As far as that memorandum goes, that memorandum was also not public and I was asked by my boss not to discuss that. It's an internal White House memorandum and I wasn't to discuss the content of that memorandum.

Mr. NAGLE. If I could just observe that, you know, I fought to get on this committee because I think, as the chairman does and as Chairman Rowe does, is that the future of this country and all the buzzwords about competitiveness, I really believe in the work this committee has done in the past and I want to be supportive.

But I will tell you in all candor that this, the run around we're having here in terms of figures and costs and that sort of thing are not confidence instilling.

Mr. NELSON. This is frustrating to you and to everybody, and it's especially frustrating to Mr. Stofan. And you know, I'm wondering if really we're getting anywhere. What we're going to have to do is, you're going to have to come to us, and Dr. Fletcher is going to have to come to us and answer specifically, without evasion, our questions before we're going to put anything in the NASA authorization bill.

Now right now we are scheduled on or about March 26th. We may shift that to accommodate our colleagues, to about March 25th. So we've got to figure out, Andy, between now and then when you can come back to us with the full support of Dr. Fletcher and tell us specifically all of the answers to these questions.

Because this committee is not going forward operating under the illusions that we operated under last year, in which we were given a firm figure as if $8 billion was the cost. And we're not going to take the lead, as we did when we got your $410 million in the budget last year. That's simply not going to occur.

Mr. STOFAN. It is my wish to bring you that program and the number as soon as I possibly can. I would like to get those RFPs released as quick as we possibly could.

Mr. NELSON. And you think that it's reasonable that that would occur between or before March 25th?

Mr. STOFAN. I'd say there's a good possibility of that, yes.

Mr. NELSON. Okay, well, let me tell you the alternative to that. And I mean, you just may as well face it. The alternative is that the NASA authorization bill goes forth and there's not anything there for the station. And if you don't have this committee fighting for the station for you, then there's some deep trouble.

Now the fact is, as Mr. Nagle said—I mean, he fought to get on this committee. This guy waged a campaign because he wants to be a part of the future of this nation. Almost all of us in here get excited about these possibilities that you have enumerated of what we're going to do. We get concerned when we know that the Soviets are up there right now in MIR conducting a number of these experiments that we can only get six, seven-day experience on that they're getting day after day after day experience on.

So I mean, you don't have to sell us on the substance. But we've got to be responsible policy makers.

Mr. WALKER. Mr. Chairman, if I could just pursue here for a moment where I was going before I yielded. The problem that we've got is that even when you give us the figures now—if I'm

quoting the White House memorandum correctly--those figures don't add up.

If you're telling us that 19 percent for infrastructure was in the original $8 billion, that means you have a plus-two add on to the figure. That brings us to 10 billion. If you say that 1 billion more was added because of the change in the design, that brings us to $11 billion. All of the sudden we have a difference between $11 billion and $16 to $20 billion. That doesn't add up here.

Mr. STOFAN. I'm sorry, there was a third part that I didn't mentioned. I mentioned, said there three and I only told you about two.

Mr. WALKER. Okay.

Mr. STOFAN. And that was my—the rest of the increase was in reserves.

Mr. WALKER. Okay, all right. The White House figure for reserves is $2.5 billion. Is that in the ballpark?

Mr. STOFAN. Not the very close ballpark.

Mr. WALKER. Not the very close ballpark.

Mr. STOFAN. No.

Mr. WALKER. Is it higher or lower than the very close ballpark? [Laughter.]

Mr. STOFAN. I don't think we should pursue that. But the difference in the numbers, of the three areas as I mentioned, the last one we didn't talk about, we did have a substantial increase in the amount of reserves that we think is necessary. And again, I think as soon as we can get the program settled and come to you, we can walk you through, dollar by dollar, line item and they will add up, and I hope we can do that very shortly.

Mr. WALKER. I hope you can, too, because, of course, the reserve factor is the fudge factor. And you know, that becomes a fairly important factor in all of this as well because we need to know just exactly what kinds of costs we're going to incur.

And one more thing. We just—I have to pursue here just as a matter of clarifying to me—the spend out for this program exceeds the President's budget in years '90, '91 and '92. In other words, the budget that's presented to us in 1988, by something on the order of $2 billion a year additional, if we are to assume the new spend-out ratio.

The space station itself would be taking $4 billion a year in the years '91, '92, and '93 that we would be spending on that program alone. Where in the world are we going to come up with that money? Has anybody looked at what we are going to do to find $4 billion in a $10 billion appropriation? Are you planning that as all add-on cost? I mean, as you're planning for this, is that going to be all add-on cost to the NASA budget?

Mr. STOFAN. No, it isn't, but I don't think I ought to discuss it any more beyond that.

Mr. NELSON. Okay, we're just going to finish the hearing here. Mr. Nagle, you had some more questions on another subject.

Mr. NAGLE. I, yesterday, with Dr. Fletcher, asked him if there'd been discussions or negotiations with the Department of Defense over the military uses or Department of Defense uses of the space lab. And he indicated that they had and they'd gone over a period of three weeks, and at the conclusion of the negotiations which ter-

minated 11:00 the day preceding his testimony a "memorandum of agreement" was drawn up.

And I asked him whether or not we could get a copy of the memorandum of agreement and he indicated that we could. I then asked him whether or not there were any interagency memos with regards to the discussions from NASA to DOD and I was told that there were. And I asked if I could get copies of those and I was told that I could.

I had a witness here yesterday who told me that, in fact, they weren't negotiations, they were discussions. They weren't protracted, that no memorandum of agreement was drawn up, that they simply worked off the draft of the contract, and that there were no written interagency memos. I now have information that, in fact, there was an agreement and that there is a national security decision directive that was prepared as a result of the meeting with the DOD.

Let me ask you first of all, were you involved with those discussions with the Department of Defense?

Mr. STOFAN. In one meeting only. I have not been involved on the day to day discussions. I was involved in just one meeting when we got together. I have not been at all—Ken Pederson, who's sitting on my right has been involved. He and Peggy Finarelli have been the two involved in every single step by step the way through this. So if you want to get into details of what happened Ken was there and he knows what happened, and I was not. I only attended one meeting.

Mr. NAGLE. Well, I'll ask you or ask him as part of the panel, was there in fact an agreement drawn up between the Department of Defense and NASA over the Department of Defense uses of the space lab?

Mr. STOFAN. Between the Department of Defense and NASA? Not to my knowledge. Ken?

Mr. PEDERSEN. Mr. Nagle, there was no agreement drawn up between the Department of Defense and NASA regarding use of the Space Station. The NSDD that you referred to is the NSDD that we discussed yesterday in the testimony that represents the conclusions of the eight to 10 agency review process, which I indicated to you, that information would be provided to the committee. There is no NASA-DOD signed agreement that I am aware of.

Mr. NAGLE. I don't want to get caught on semantics. Was there a paper prepared that reflected the interagency understanding?

Mr. PEDERSEN. Yes, sir. The results of conclusions of the interagency review process are recorded in the NSDD document that I understand the National Security Council will inform the committee about.

Mr. NAGLE. Okay. Then I asked yesterday, I had some questions with regards to some agreements, a proposed agreement between the United States of America and Japan, and I specifically asked about Article 9, I believe, paragraph 5, which provided in there—were you here yesterday?

Mr. PEDERSEN. Yes, sir.

Mr. NAGLE. And I asked about that language there what it meant, with the language that says—and I quote again today, "The United States may use the space station within NASA's allocations

of user accommodations and utilization of resources for any purpose, including national security purposes."

And I'd ask you again today, can you shed any light for me in terms of what that means?

Mr. PEDERSEN. I believe I can. That statement indicates that the Space Station or the U.S. elements of the Space Station is meant to service and provide services to a broad variety of users. It is a civil Space Station, operated by NASA, but is a national facility available to use by a variety of national users, both government and private sector, including the Department of Defense.

That is an understanding that our potential partners abroad have been aware of from the beginning. There is nothing new in that, Congressman. The Department of Defense uses other national facilities, such as the Space Shuttle. And it is meant to indicate nothing more than that the national security users will be allowed to use the Station, assuming that that use is consistent with the peaceful purposes to which the Station is dedicated. And of course, all of our national and international laws and obligations, including the outer space treaty and others that speak to prohibition on weapons and mass destruction and so forth.

Mr. STOFAN. I might add on that, that I have talked with the elements at the Department of Defense because in designing the Station we take into consideration all of the users. And we've asked all of the users and different government agencies to come to us and say, what are the potential use you have of the Station so that when we design it it can be as versatile as possible.

The Department of Defense, as of today—and it's been asked repeatedly over the last six months I've been here—have no identified use for the Space Station at this time. And they have given me and my people no requirements whatsoever to design this Space Station to. And that's where we stand today. Now in the future they may come up with a requirement; I don't know.

Mr. NAGLE. And the directive that you're going to send me will reflect what you just told me?

Mr. PEDERSEN. Yes, the directive that we've referred to is the basis on which the new IGA, the intergovernmental agreement that you have in your possession was based on. You will find that they are consistent. If they are inconsistent, I would want to be the first one to know, because that was not the intent.

Mr. NAGLE. So as I understand this at the present time, that this committee or the Congress put rather restrictive prohibitions on DOD's use of the space station. And apparently, your understanding is that the DOD doesn't having any planned uses, and NASA not anticipating any planned uses would not necessarily object to that; is that correct?

Mr. PEDERSEN. I would imagine—I cannot speak for them—but based on the conversations that we had in these review sessions, DOD while having no identified requirements and being forthright in saying so, have indicated that since we're looking at a facility that will operate for 20, 30 years, they would like to have the option retained for them to make use of that facility should their research requirements lead them in that direction. So I would imagine they would not favor such a restriction.

Mr. NAGLE. Let me just pursue this for a minute. First of all, is it true—and if you don't know, tell me you don't know—that the proposed other countries that are going to go into this agreement with us have expressed some rather severe reservations about the language that I quoted to you, have they not?

Mr. PEDERSEN. I'll answer that in two ways, Congressman, if I can. Last week we had a meeting in which the new agreement was briefed to high government officials of the three major negotiating parties, the European Space Agency, Japan and Canada. There was a lively discussion as to the overall text as well as some of the specifics of it. At the end of which a joint statement was issued in which all partners indicated their intention to go forward with the negotiations.

The negotiations with the Europeans are taking place right now in Paris. I have some initial reports that today's discussions went reasonably well. I think it is very fair to say that there are elements in the new agreement that the potential foreign partners are not completely happy with. And they involve management, they involve time allocations. So the agreement was not tabled with the notion they would be pleased with it.

Mr. NAGLE. I appreciate the depth of that, but my specific question was, objections have been raised by our foreign cooperating partners, specifically to the language that I quoted to you; is that not true?

Mr. PEDERSEN. There have been requests from at least two of the partners for explanations and operational definitions as to what the language you are referring to means. And that is being discussed with them this week and next week. And I will be in a better position, or someone at NASA will be in a better position in a couple of weeks to tell you whether we have clarified that to their satisfaction or not.

Mr. NAGLE. Let me ask, if I can, to just follow up on that so that I for my own satisfaction and the committee can stay posted on this. That term, national security purposes, has in fact not even been defined in the contract by our own government, has it?

Mr. PEDERSEN. National security purposes is a general set of assumed requirements that have not been defined because the DOD has not defined those requirements.

Mr. NAGLE. I want to quote you from a telegram sent by our Department of State that says, advising and requesting it be presented to the Japanese. "In presenting text embassies should make the following points: The draft is incomplete in several respects. It omits the articles of definitions."

Now when do we plan on defining that phrase, or do you plan on defining it? Who's going to define it?

Mr. PEDERSEN. The definitions are being developed right now. But that's a fairly straightforward legal operation. But we cannot discuss the agreement on the text until all of the definitions are completed.

Mr. NAGLE. Who's doing that? Is that intergovernmental agency again?

Mr. PEDERSEN. Yes, that's an activity undertaken by an interagency process, that's correct.

Mr. NAGLE. Now let me follow up with one last thing, if I may. Is it true that NASA went into these negotiations or these interagency discussions without any prepared comments other than the contract itself?

Mr. PEDERSEN. I think that to characterize these as negotiations is——

Mr. NAGLE. I don't want you to get stopped on that. I'll rephrase the question. Is it true that NASA went to these meetings—there were meetings, weren't there?

Mr. PEDERSEN. Yes, sir.

Mr. NAGLE. Okay, you went to these intergovernmental agency meetings without any prepared points that you wanted to make or definitions that you wished retained or anything else? You just went in there with a copy of the contract?

Mr. PEDERSEN. We went in with a copy of the intergovernmental agreement that we, together with State Department, had developed over a long period of time. That represented our position paper, if you wish to choose those terms. That represented what we felt was a viable negotiating position and consistent with national interests. And that was our position, yes.

Mr. NAGLE. All right, now, before going to those meetings—and to use your term, your negotiating position—were there inter-NASA memorandums in terms of comments on this document in terms of what it meant and what it didn't mean.

Mr. STOFAN. I was involved in part of that process and say that, there were not inter-memorandums written stating people's position. That the communications between, say, Peggy and Ken and myself is, we sat around a table and had that agreement laid out before us, and discussed the language that we thought would be appropriate in it. Then the discussions went on with State.

When they agreed then on a set of language, that took forward to State and NASA position. So there are a lot of discussions, but we didn't mail memorandum back and forth to each other stating positions.

Mr. NAGLE. I'm not talking about mailing back and forth, I'm just talking about inside your own agency. When you had these meetings and discussed it among yourselves, you didn't write down what you decided?

Mr. STOFAN. That was the memorandum that came out of it. That's what was written down. That's the verbal thing that was transferred into a position that was taken in on that first memorandum. I think that represented the agency and State on what our position was.

Mr. NAGLE. All right, fine. Yesterday you also, I believe, agreed to furnish me with copies of the changes that were made from the original draft to the draft that came out of DOD. And I asked only for substantive changes. I assume I can still get those documents.

Mr. PEDERSEN. Yes, we will need to get together with State Department and do that.

Mr. NAGLE. NASA's original draft and then the substantive changes were made and the explanations as to why those substantive changes were made.

Mr. PEDERSEN. Yes. One small correction, but it could be meaningful. The intergovernmental agreement we're talking about is a

State Department document. It is not a NASA document. However, we will provide the information you've requested.

Mr. NAGLE. Thank you. Thank you, Mr. Chairman.

Mr. NELSON. Other members of the committee? Mr. Chapman.

Mr. CHAPMAN. Thank you, Mr. Chairman. Let me ask, based on the discussions that are going on, negotiations or whatever they might be classifed at OMB between NASA and OMB at this time and further definition, am I to assume that that in no way would effect the requests for FY 1988, the number that we see here, $767 million? That is the number for next year. Is there any chance that would change as a result of what's going on somewhere else today?

Mr. STOFAN. Without knowing the entire range of what is going to be forwarded for a final decision, I don't know how to answer that. Someone could recommend—it surely wouldn't come from my lips—but doing something very drastic to the Station, and then we might not need that money. I hope that never appears on an option paper. But again, the process is just going on so I really can't answer it honestly.

Mr. CHAPMAN. So from the standpoint of funding even the authorization that we are currently considering and then subsequent appropriations for this next fiscal year, Dr. Stofan we're not in a position to know that 767 is going to be that number that's requested for sure?

Mr. STOFAN. I think of anything, the discussions that have gone on to date, that I won't come and ask for more.

Mr. CHAPMAN. Just one last question. What would be the effect on the concept if our foreign partners dropped out of this project, for whatever reason. What effect would that have on us?

Mr. STOFAN. With one exception, from day one designed this Space Station to be fully functional without our foreign partners. And the one exception is with the Canadians providing a remote manipulator arm. We're providing the transporter, they're providing the arm. And if they dropped out, we would then have to provide that arm to the Station, and that's a few hundred million dollars.

But with the European Space Agency and the Japanese, it is an add-on to the Station. And without them, we have a fully functional station that can operate and return the science and technology and commercial adventures that we say we want to do.

Mr. CHAPMAN. Thank you, Mr. Chairman.

Mr. NELSON. Other members of the committee?

Mr. WALKER. Mr. Chairman?

Mr. NELSON. Let me get Mr. Perkins and then Mr. Walker. And then I have some concluding comments and then we'll adjourn. Mr. Perkins.

Mr. PERKINS. Mr. Stofan, I have a couple of questions. One, is there any type of research that's being done in regards to the station with tethers presently, or is that in any of the plans?

Mr. STOFAN. It is my understanding—and I'll ask Tom to comment on this—that there is a tether program within the agency associated with the space transportation system. In fact, when I was running science, six, seven, eight years ago, the tether was part of a science program. And we have a study underway to look at the tether with the station. But I'd like Tom to comment on it.

Mr. MOSER. During the definition phase of the program, we looked at various concepts and its adaptability to tethers and the unique characteristics that it has. To answer your question though—there's nothing specifically in the program right now for tethers and tether experiments. But the intention is not to preclude such experiments.

Mr. PERKINS. I understand that that's a pretty interesting area from everything I've seen.

Mr. STOFAN. There are two areas, Tom, I think that are of interest that we are looking at and don't have answers. Now one is that we have a not only up weight problem with the shuttle in order to get enough mass up to support the people and get the structure up. But there's also a down mass problem in that at the baseline we were bringing back everything that was taken up.

There was a concept proposed that's being evaluated, they're looking at a tether to de-orbit disposable trash. And that's one thing—I have not seen the material myself yet but that's being prepared.

The other area of looking at a tether that if in the future when we understand the effects of zero gravity on man, long term effects and the countermeasures, we want to create an artificial gravity field. Again, you can put two cans at the end of a tether cord and create—depending on the length—any gravity field that you want.

So there were some preliminary studies in those two arenas, neither of which though are near any final type thing. But they're interesting concepts.

Mr. PERKINS. Hasn't there been some talk as well about using tethers for some of the incoming vehicles from, let's say, on a revolving spaceship one of the little vehicles that goes and picks it up and then comes back, and using tethers as either end? I've seen talk about that. You know what I'm talking about?

Mr. MOSER. There are a couple of things. One is you can do that, depending on where this other vehicle is located, to transport fuel. And I should say that, as Andy said, all these are in a conceptual stage right now. They're pre-conceptual, they're study phases. But you can place a vehicle like that and you can transport fuel, say from a space station up to this little vehicle as you describe it.

Or you can locate it differently so that you release that vehicle or that mass object and you cause it to lower its velocity and at the same time increase the velocity of the Space Station, and increasing its altitude so it makes up—so those types of things are being looked at now with great interest. And as we spoke, too, of some of the internationals, we're working very closely with the Italians on this.

Mr. PERKINS. I would hope to see some type of activity there. Just looking at it it looks like a very promising field.

Mr. STOFAN. Frank, you had a comment on that?

Dr. MARTIN. Mr. Perkins, I think you'd also find some interesting tether discussions on the Paine Commission report on the long range plans to go to Mars and things of this sort.

Mr. PERKINS. Yes, I read that.

Dr. MARTIN. The tether is actually hanging from the Martian satellite and used to de-orbit.

Mr. PERKINS. That was very interesting. The second thing that I would be interested in is in terms of some of the future—of how many space stations we're eventually talking about. I've seen a variety of ideas, talking about a number of space stations. One, is to put it at a libration point L-1, in the space commission report, 35,000 miles from the moon. I have no idea why that's the best point to launch some sort of spaceship towards Mars.

What other plans presently do you have in terms of number of space stations?

Mr. STOFAN. Right now, other space stations, the answer is none at the present time. But we have in process an evolutionary study of looking at the Space Station. This has been an ongoing effort for several years and that's handled as a separate entity within the program. And it's a separate line item within the budget so that we keep in mind that we're designing the Space Station to evolve.

And we've had several workshops, and some of the concepts, long range concepts out of the workshop was that once you grow the station to a given size for a research laboratory, rather than keep building on it more and more and more, perhaps you want to build another station for another—for instance, assembly depot, a storage depot. Maybe it will go off into the area of a large manufacturing area for microgravity manufacturing. And they're looking now, rather than build one huge complex, that it may be more efficient to build several smaller ones.

But this is well after the year 2000, well in the future. And it's only conceptualizing to see if any of these concepts would have an effect on what we're doing today. And that's why we keep looking in the future, should we do something a little different now so we don't preclude an option in the future.

Mr. PERKINS. It would kind of depend on what goal we had, what description it went.

Mr. STOFAN. Exactly. Very, very much so.

Dr. MARTIN. One important thing to remember is that all of these other space stations in different orbits, whether they be about the Earth, moon or Mars all involve one important element. And that's a low Earth orbit space station to get you there. And that's the one we're talking about.

Mr. PERKINS. That's all. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Walker?

Mr. WALKER. Thank you. I'll stay away from money this time.

You mentioned a couple of words that bothered me in the course of your testimony. You said that the baseline station would be a man-tended station.

Mr. STOFAN. If I said that, it was in error.

Mr. WALKER. Is a permanently manned station?

Mr. STOFAN. The baseline station is the picture that I showed, the full up station with the modules with the platforms. That's the baseline.

Mr. WALKER. Which is a permanently manned station rather than a man-tended station?

Mr. STOFAN. Yes, absolutely, yes.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Any further comments from the committee? We're delighted to have our new chairman of the International Cooperation Subcommittee here who is also a member of this committee.

Mr. HALL. Thank you, Mr. Chairman. And I, not knowing the questions that have already been asked and the answers given, I feel very free with the access that we've always had to get additional questions answered. I might have asked about the life sciences and the proportion of life science to material science and all that. But I'm sure you've answered that here.

What I'm basically interested in, and I think what the committee's jurisdiction is aimed toward is transfer of technology or support or cooperation with other nations to lessen the cost that Mr. Walker is so interested in. And I feel free to call on you for information down the road on that. I thank you and I thank the chairman.

Mr. STOFAN. We'd be happy to.

Mr. NELSON. I want to close out this hearing. And you're going to have plenty other opportunity in the future because, Mr. Hall, we're going to have to have another visit on some nailed down figures.

Mr. HALL. Thank you, Mr. Chairman.

Mr. NELSON. I have two documents in my possession, and some of them—these two documents are mutually contradictory. On the one hand I have a memorandum to the President from his budget director, James Miller, revised cost estimates for the space station. And what he says is, the figure that Mr. Walker has reported, that it's not $8 billion, that it's $14.5 billion in '84 dollars, which he says is $21 billion in current year dollars.

That by the way, in memorandum is refined later on to say that, no, it's actually a figure that's higher than that because there was, in the new estimate there was a planning phase that was originally included in the original $8 billion, and now that is omitted. So that the estimate on a comparable basis would be $15.1 billion in '84 dollars, which is 89 percent above the original $8 billion estimate.

Now that's the document that you can't talk about because you've been manacled at this point. And that's what we're going to have to talk about in the future.

On the other hand, also from the Office of Management and Budget, I have a copy of a letter from the deputy director to Dr. Fletcher as administrator of NASA, a letter talking about the future budgets of NASA. And in that is an enclosure that gives OMB's cut at what the NASA budgets are going to be over the next six years, through the year 1992.

And instead of it being an ascending budget, which is if this nation is going to achieve it and continue its greatness in space of which its people expect and demand, it is a descending budget. Not even calculating cost of living adjustments which are not here. It goes from a $10.5 billion budget which we're in this year out to 1992 to a $10 billion flat budget.

Now the reason that I say, first of all, that's woefully inadequate for the nation to achieve. We ought to have a $15 billion budget by the year 1990, much less what OMB is projecting, a $10 billion budget in the year 1992. But I said that the documents are mutually contradictory, because there's no way that you can be spending

$4 billion a year in the years 1992, '93 and '94 just for the space station, as Mr. Walker pointed earlier, in a $10 billion NASA budget.

So we have some serious problems in front of us.

Mr. STOFAN. I would totally agree with that.

Mr. NELSON. All right. Then on that note we look forward to a return in which we can answer some of these questions. The meeting is adjourned.

[Whereupon, at 3:54 p.m., the subcommittee meeting was concluded.]

# 1988 NASA AUTHORIZATION

TUESDAY, MARCH 3, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 9:37 a.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Today we are going to continue our hearings on the 1988 budget request by NASA. We are going to hear from the Office of Space Science and Applications, both from the NASA managers and from outside witnesses that represent the science community.

As we hold this meeting I think it is appropriate to recognize that today our representatives are in Paris to present to the International Council of Scientific Unions our plans for the International Space Year. This year was conceived by the Congress two years ago as a follow-on to the International Geophysical Year.

As a matter of fact, it was this committee, when meeting with the Soviet President Gromyko, that we proposed to him that we make 1992 the International Space Year. His reaction was one of interest, of curiosity, and he was reflecting what had happened in their scientific community where that idea was beginning to percolate.

This International Space Year indeed could be a grand year of international research and discovery, and therefore it could be a year in which we could celebrate our achievements in space.

Now, in passing the legislation that established the International Space Year, the Congress intended that the United States would be a leader in this effort. We envisioned that scientists around the world would be reviewing the data from our earth observing satellites, from our great astronomical observatories, and our magnificent planetary exploring machines, and all of those combined, we thought, would be giving us information about ourselves and our place in the universe. Our leadership role in that International Space Year would be an appropriate milestone to mark the 500th anniversary of the discovery of the New World.

What Congress did not fully appreciate at the time was the crisis that was developing in the space and earth sciences. The stark realities that now confront our space science program have been brought to light by the Challenger accident but were already rooted in the management and budgetary decisions stretching back nearly a decade ago. So it is natural to question whether we can

realistically fulfill the leadership role that the International Space Year legislation intended.

The cancellation and delay of major science programs such as what has been proposed by NASA, to delay Mars Observer by two years, completely eliminating, as NASA's budget proposed, the Advance Communication Technology Satellite and delaying Spacelab and cancellation of a number of those missions, does not suggest that we can step forth with any kind of leadership, yet it has been the view of this committee that we must. Our task, then, is to find a way, Dr. Edelson.

So today we look to you as the Associate Administrator of Space Science and Applications. Unfortunately, this is going to be the last time that you are going to appear as a representative of NASA. You will be back with us many times because we will ask you to come back. We value your advice. I want to congratulate you on your years of service to NASA and to the science community, and we certainly wish you well in your future endeavors.

You also have with you Dr. Glenn Mason. He will represent the Space Science Working Group of the American Association of Universities, and that will be a welcome comment on the state of science from the academic point of view.

We will also hear from Dr. Lou Lanzerotti, representing the NASA Science Advisory Council. I want to commend you for your work on the Council and the recent report, "The Crisis in Space and Earth Science." This is going to do much to set the course toward a much-needed recovery in the science program.

I think now is the time for us to come together. This is the time of commitment. If you notice that I have a little bit of emphasis and emotion in my voice, then you can understand why I do, because now is the time. There is an old southern colloquialism: It's time to fish or cut bait. So let's see if we can go out and start fishing.

[The opening remarks by Mr. Walker, a Representative from the State of Pennsylvania, follow:]

OPENING REMARKS OF REPRESENTATIVE ROBERT S. WALKER

Good morning, Mr. Chairman. I join you in extending a warm welcome to our witnesses here today.

The activities of our Office of Space Science and Applications are important to all mankind, as this program serves as the flagship of human curiosity in our epic voyage of discovery through our solar system and beyond.

This generation has been uniquely favored in all of human history. We have participated in the exploration of the far reaches of space that our ancestors have dreamed of exploring for thousands of years.

I am pleased to have the opportunity to help NASA plan the future of space exploration. The people of Lancaster Country Pennsylvania have a long history of providing the tools used by explorers and pioneers. Long ago it was the Conestoga wagons built in Lancaster that carried a generation westward, and the long rifles made by Pennsylvania craftsmen in Lancaster County provided both food and protection. Today, we still stand ready to provide the heat-pipe technology that will provide the necessary electrical power on voyages of exploration far beyond our sun.

I must express considerable concern about the future of our science programs. The science budget is down in both absolute terms, and as a percentage of the total NASA budget. We face considerable uncertainty in the shuttle schedule and projected flight rates for some years to come. We all realize that NASA is going to have to return to ELVs, particularly for those missions that do not require the active intervention of astronauts. And, we once again see the short-sightedness of OMB in their attempts, once again, to kill the Advanced Communications Satellite Program.

While I am a firm believer in the private sector, we cannot lose sight of the fact that the space applications program, in areas such as communications, materials science, and remote sensing research, is a good investment in America's future. The money we invest there today will pay large dividends in the private sector in years to come.

Thank you, Mr. Chairman.

Mr. NELSON. Dr. Edelson.

**STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY SAM KELLER, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS; DR. JEFFREY ROSENDHAL, ASSISTANT ASSOCIATE ADMINISTRATOR FOR SCIENCE; AND RONALD KONKEL, DIRECTOR, ADMINISTRATION AND RESOURCES MANAGEMENT DIVISION**

Mr. EDELSON. Mr. Chairman and members of the subcommittee, it is a great pleasure to be here today. I appreciate very much your supportive remarks, Mr. Chairman, and I will address some of the problems that you mentioned in my presentation of the proposed fiscal year 1988 budget request for Space Science and Applications.

I am accompanied at the table today on my immediate left by Sam Keller, my deputy, by Dr. Jeffrey Rosendhal, our chief scientist, and on my right by Ron Konkel, the Director of Administration and Resource Management of OSSA.

With your permission, Mr. Chairman, I would like to submit my written statement for the record and summarize it now in an oral presentation.

For the past 28 years, the Space Science and Applications Program has been a vital and important part of our Nation's space effort. It has made significant contributions to our knowledge of the distant universe, our cosmic neighborhood, the solar system and our home planet Earth in science. In applications, it has reaped practical benefits from space systems for life on Earth in communications, in weather prediction and Earth resource assessment, and even in saving lives through our satellite search and rescue operation.

I am confident, Mr. Chairman, that the outstanding tradition of excellence in space science and applications will continue in the future.

As you are aware, the year 1986 began as one of great anticipation. We called it the Year of Space Science, to recognize the large number of important and exciting space science flight activities which we expected to come to fruition in that single year. These included the Voyager encounter with Uranus in January, two planetary missions, Galileo and Ulysses, both planned in May, two major Spacelab missions, ASTRO-1 to observe Halley's Comet in March, and Atlas-1 in August to perform atmospheric research.

Finally, we planned to launch the Hubble Space Telescope in October of 1986, our highest priority science mission. Of this ambitious and exciting array of missions, I am sorry to say, Mr. Chairman, only the Voyager encounter with Uranus became a reality in 1986.

It was the highlight of the science program for 1986 and a magnificent one. Voyager 2 was launched in 1977, (figure 1). On January 24, 1986, the Voyager 2 spacecraft, after a flight of 8½ years, made a remarkable encounter with the Uranus system nearly 3 billion kilometers from Earth. Our closeup observation of the planet revealed it to be even more mysterious than we had expected, with a fascinating layered, blue-green atmosphere.

Voyager photographed the nine known rings for the first time and discovered two more. This one image (figure 2) which I will show of the smallest of the five moons, Miranda, surprised us with much more extensive and varied geological activity than we had expected. It shows a complex and totally unique surface. It shows a patchwork of different terrains, including huge, icy canyons more than 10 kilometers deep.

Analysis of the data returned from Uranus will allow us to better understand this faraway unique world and how it relates to Planet Earth and the rest of our solar system.

Then four days after that magnificent encounter of Voyager with Uranus, the Space Shuttle Challenger blew up. The loss of the Challenger, the two-year downtime in launches and the termination of the Shuttle/Centaur program, which I have termed a triple whammy, have had a severe impact and have required a massive replanning of our entire science and applications program.

Our flight program, originally based on 50 Shuttle missions from the years 1986 through 1992, was reduced to only 17 in the New Manifest. This has required stretchout of our surviving missions by an average of some three years. Most of our planned Shuttle-attached payloads have slipped more than three years, and many of those into the 1993 to 1995 period.

Unfortunately and as you mentioned, we have had to cancel several Spacelab missions. We are now participating in agency studies on the use of expendable launch vehicles to launch some of our free fliers. Our Planetary Program has been very adversely affected, and we are currently reviewing it intensively to make the best use of available flights.

We are working extremely hard to maintain the health of our scientific program. Our strategy to maintain momentum during the flight hiatus include what we refer to as our Vitality Package. This is an infusion of funds to support various scientific disciplines, particularly the university research community. It should enhance the attractiveness of space science to students as a viable research option during the hiatus of flight opportunities, and it will support continued research and data analysis from previous flight missions. It will give increased attention to the Suborbital Program of rockets, balloons, airborne flights as a source of near-term and continuing flight opportunities.

This Vitality Package will provide some immediate relief, but these funds, of course, do not initiate major long-term obligations in our program.

Thus, Mr. Chairman, although there is certainly no way to paint a happy face on the present situation in space science and applications, we have developed a reasonable plan to carry us through the flight hiatus and to put us in a strong position to conduct first class science missions upon the resumption of flight.

I would like now to briefly describe the fiscal year 1988 budget request (figure 3). The total R&D request for all of SSA is $1,508,300,000. This funding will support a balanced program in the various disciplines and will also fund the Vitality Package needed to sustain a healthy research base through the Shuttle flight hiatus.

I am pleased that the 1988 budget request provides funding for one proposed new start, the Global Geospace Science Program, (figure 4) which will provide full U.S. participation in the International Solar-Terrestrial Physics (ISTP) Program, involving a cooperative effort with the European Space Agency and the Japanese Institute of Space and Astronautical Science.

Mr. NELSON. Dr. Edelson, one of the blessings of this subcommittee is that we have some really hard-charging new members, and we have two of those new members with us today. Why don't you go into a little more detail about this particular mission and give them some background on it.

Dr. EDELSON. The new start, which is included in our budget, includes two United States spacecraft, Wind and Polar, shown on the chart (figure 4).

Mr. NELSON. Would you see if you can focus that a little bit better, please.

Dr. EDELSON. I might turn to Dr. Shawhan, who has been acting as the originator and program manager of that. Stan, if you will come up here, I will let you describe that.

Let me say that the purpose of this program is to gain an understanding of the very important relationship between the Sun and the Earth, between the solar effluence, the particulate and radiative output of the Sun and this planet on which we live, through the solar wind and its connection with the magnetic field around the Earth, known as the magnetosphere.

The point is that this is a very complex system, and in order to understand it, we have to observe it simultaneously with a number of different instruments on a number of different spacecraft located between the Sun and the Earth, around the Earth in different orbits and beyond the Earth in the geomagnetic tail.

I will ask Dr. Shawhan now, addressing this particular Vugraph, to point out what the various spacecraft are and what they do, with an emphasis on the U.S contribution.

Dr. SHAWHAN. Mr. Chairman and new members, let me just give a quick review. In 1983 when Dr. Edelson came on board, he realized that there was an international interest in understanding the environment of the Earth and directed us to look to our colleagues in Japan and Europe to see if we couldn't put an international program together because the Earth is not just ours.

We did look at the possibility of doing that and we realized that there was interest in the other major space agencies. So the program you see before you is a combination of assets from NASA and the other nations. In particular the Soho and Cluster spacecraft are being provided by the European Space Agency, the Geotail spacecraft by the Japanese Institute of Space and Astronautical Sciences, and it is the Wind and Polar spacecraft that are part of the new start which we call the Global Geospace Science.

We have been fortunate in the past to have reconnaissance spacecraft that have looked at the Earth and the Earth's environment, Explorer 1 being the first one, and the early Explorers discovering the Van Allen radiation belts. We have now moved out under U.S. leadership to identifying the major environment around the Earth, but again, these are shots in the dark, in a sense. We go out and we make measurements and we know something happens, but we haven't been able to study it as a system.

So by having multiple spacecraft up there, it is like having multiple sensors when you have an electrocardiogram. Your heart goes pump, which is the Sun, the energy source, and you look at the response of the rest of the body. All the elements are important, and it is important to make the measurements simultaneously.

So the flotilla of spacecraft is not a luxury; it is a necessity for understanding the system. We realized that we could not do it by ourselves. We couldn't produce enough spacecraft in that time frame. However, we have taken the leadership in suggesting the program and coordinating the program with our international partners.

Just to give you an idea, the Soho spacecraft out in front has optical instruments. It is an observatory in the sky that views the Sun with microscopic clarity to understand the small-scale structures of the Sun. So we see the Sun burp, as it is, put out a solar flare, and then by using the optical instruments on Soho and the measurements on the Wind spacecraft, the NASA spacecraft, we can see that disturbance come towards the Earth.

It arrives at the Earth about two days later, and at this point the particles and the fields that have left the Sun interact with the Earth's magnetosphere, the vicinity of the Earth that we call geospace surrounding the Earth. It has neutral matter and mainly plasma matter.

The other spacecraft then make measurements of the response of the Earth's system to that, and the Polar spacecraft, the other major NASA spacecraft, not only measures the fields and particles as they map into the Earth's magnetic field region, but we also have cameras on board to view the aurora.

You may have seen some of the spectacular photographs from the Explorer spacecraft where you can see the whole aurora oval in the northern or southern hemisphere dancing around. That is an indication of energy that is being dumped into the atmosphere, which competes with the energy that comes from the radiant energy of the Sun, the daylight that we are aware of that has the 24-hour cycle. But in addition, there is this irregular input that comes out of the Earth's magnetosphere, driven by the Sun indirectly, that adds to that in a random fashion, and the two energy sources combined are what drive our weather system on the short term and our climate system in the long term. So we need to understand both inputs, and this system allows us to do that.

So we can understand inputs to the Earth, long and short-term effects on the near-Earth environment, and also the Earth as an example of other astrophysical bodies such as comets, such as other planets and probably other astrophysical regions where there is a central body and a fairly intense magnetic field and an interaction

between that field and, for example, other stars and binary star systems.

So we think it is a very fundamental program that benefits mankind, and I should point out, Mr. Chairman, our launches are scheduled for 1992, so it fits in very well with the International Space Year as a major thrust and provides basic information on physical processes throughout the universe.

Mr. NELSON. Will most of those spacecraft on your chart be launched in 1992?

Dr. SHAWHAN. Yes, sir, most will. The Wind, Polar, and Geotail are scheduled for 1992. The CRRES we are hoping to launch as early as 1989. It right now is on the manifest for 1992. The Soho and Cluster European spacecraft will probably be launched in 1994 because of the availability of the Ariane 5 vehicle.

Mr. NELSON. Okay. And Ulysses interacts with all of these as well.

Dr. SHAWHAN. That is correct. We are hoping that Ulysses will be up and operating, and it is part of our overall understanding of the system because it will give us information about the Sun and the solar polar regions at the same time. It turns out that if we can get Ulysses launched in the 1989 or 1990 time frame, it will be passing over the poles of the Sun at the same time these spacecraft begin their operations.

Mr. NELSON. For the new members, Ulysses was one of the major planetary probes that was to be launched last year in the month of May aboard the Shuttle in the same month as the Galileo probe, and basically what Ulysses does is that it goes out of the solar plane. Normally our spacecraft go into that solar plane, but this one uses the gravity assist of Jupiter, goes out of the solar plane so that we can make measurements and observe from a place where we have never observed, and that is where you see Ulysses up there above that solar plane in this chart.

That was an excellent explanation. We thank you, Dr. Edelson.

Dr. EDELSON. We are absolutely delighted that you asked those questions, Mr. Chairman. It gave an opportunity to speak about our new start and many features of our science program that we are particularly proud of. This particular program, as Dr. Shawhan described it, provides first-rate science and an understanding of the solar-terrestrial interface. It also provides a practical benefit in knowledge of climate effects on Earth.

It is a triumph of international cooperation with, as Dr. Shawhan pointed out, U.S. leadership. Here is a true international program of great dimensions in which the United States with this new start will be in every respect the leader of the program. I like to point out on this chart that there are spacecraft of these various nationalities, and one of the spacecraft, CRRES, is a joint U.S./DOD science mission. So we have got the world community all working together on this program.

Mr. NELSON. How in the world did you get DOD to pay for a spacecraft?

Dr. EDELSON. DOD has, as we all know, buried in their program very valid scientific interests, and this is a program of scientific merit with practical benefits to DOD in there, and one way or another we worked it out, and it has been a very happy and mutually

advantageous arrangement for us and DOD and for the international scientific community.

Perhaps I should return, reluctantly, to the budget. Our fiscal year 1988 budget, shown again on the board (figure 3), will support our major flight programs. We will continue the maintenance testing and certification of the Hubble Space Telescope. It will support the Galileo and Ulysses missions.

Mr. NELSON. Let me stop you right there. I want our members to know also—isn't the figure something like, just to maintain the Hubble Space Telescope on Earth until we can fly it, isn't it something like $6 million a month?

Dr. EDELSON. Yes, it is, Mr. Chairman. This is a very fine instrument. It is probably the finest optical instrument that has ever been built of any size for use on the ground or in space. It is necessary to maintain this instrument in an ultraclean environment, to keep testing and exercising its rotary mechanisms and testing the electronics. It is necessary to keep all the scientific teams together as well as the engineering effort at prime contractors, Lockheed and Perkin-Elmer, and many of the subcontractors, and all together over this roughly 24 months delay in launch, that works out to be about $6 million to $7 million per month. That is expensive.

The program does support that. That money is in there. Same for funding on Galileo, and same on funding for Ulysses, much of which the Europeans bear.

The request also continues the development of programs to come, the Gamma Ray Observatory, the Upper Atmosphere Research Satellite, Magellan, the Venus radar mapper mission, the Mars Observer, and this year's new start, the Ocean Topography Experiment, TOPEX. It will support critical activities in our life science program, our microgravity science and applications discipline, and other science areas.

The budget will support the continuation of our valuable and productive Explorer program and the activities necessary to maintain the readiness of Spacelab and other Shuttle attached missions when flights resume. It will also support our development work on instruments and facilities for early use of the Space Station and will provide funds to implement the Vitality Package of which I spoke earlier.

Of our total of $1,508,000,000, I might point out particularly that we expect to spend some $215 million in university research. There are two issues I will mention in the budget which you have already noted, Mr. Chairman. Consistent with administration policy, we are not requesting fiscal 1988 funds for the Advanced Communications Technology Satellite. Also, we have not provided adequate funding in the fiscal year 1988 budget to keep the Mars Observer on the development schedule for a 1990 launch.

We are currently studying with great intensity the possibility of launching the Mars Observer on a Titan 34-D expendable launch vehicle. We hope to be able to work out both the launch and funding problems so that we can keep the Mars Observer on schedule. However, if unsuccessful, we must delay it because of the 25 or 26-month window to Mars until 1992, from August 1990 to September 1992.

In conclusion, Mr. Chairman, the fiscal year 1988 budget request for Space Science and Applications will sustain a strong program through the Shuttle flight hiatus. It will ensure our readiness to implement the approved flight projects as soon as we possibly can.

I would like to conclude on a personal note, Mr. Chairman. As you noted, I have announced that I will be departing NASA this spring. In the five years that I have served as Associate Administrator for Space Science and Applications, I have had the great pleasure of serving with an outstanding group of people, including the individuals at the table with me this morning and in the first couple rows of the audience today, those individuals in OSSA and other individuals throughout NASA and in our allied industrial and university communities.

I am very proud to have been able to play a part in the advancement of our nation's space program.

I would also like to thank you, Mr. Chairman, and the other members of the subcommittee for your personal interest and support during all or much of my tour as Associate Administrator at NASA.

Thank you very much.

[The prepared statement plus answers to questions asked of Dr. Edelson follow:]

Hold for Release Until
Presented by Witness

Statement of

Dr. Burton I. Edelson
Associate Administrator
Space Science and Applications

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
United States House of Representatives

Mr. Chairman, Members of the Subcommittee:

I am pleased to be here to present the proposed FY 1988 budget for the NASA Space Science and Applications program. Over the past 28 years, this program has consistently made significant contributions to our scientific knowledge of the universe and our own planet Earth and developed practical areas of space systems and technology for the benefit of all mankind.

The year 1986 began as one of anticipation for the Office of Space Science and Applications (OSSA). It was heralded as "The Year of Space Science" in recognition of the large number of major space science flight activities which we expected to come to fruition in that single year. In January, the Voyager 2 spacecraft, launched in 1977, would make a remarkable encounter with the planet Uranus and would return spectacular images and other scientific measurements of the planet taken at close range. Two major planetary missions were scheduled for launch in May on the Space Shuttle: one to Jupiter (the Galileo spacecraft and probe) and the other over the poles of the sun (the joint NASA/ESA Ulysses mission). Two major Spacelab missions (ASTRO-1 in March to observe Comet Halley and Atlas-1 in August) were planned to carry out extended scientific investigations in orbit. The Hubble Space Telescope, scheduled for launch in August, was to begin a decade or more of exploration of the universe.

Only the Voyager encounter with Uranus became a reality in 1986. The loss of the Challenger required a massive replanning of the entire space science and applications program.

Following the Challenger disaster, the first priority was clearly to identify the causes of the Shuttle accident and to develop and implement a recovery plan that could get the Shuttle fleet back into service safely. NASA could then provide a solid planning base upon which Space Shuttle users (government and private)

could make their own recovery plans, addressing their particular programmatic needs. When appropriate, we have consulted with our international partners so that they would be able to adjust their activities.

OSSA was an active participant in the Agency studies and planning exercises carried out in 1986 to reestablish a workable Shuttle manifest and to address the programmatic impacts of the schedule delays. We carried out our own assessments of launch and schedule requirements for programs and initiated analyses of expendable launch vehicles now incorporated into the "Mixed Fleet" study carried out by the Office of Space Flight.

We have been working hard to set a plan for recovery of the program, and to maintain the health of the Space Science and Applications program and have had to make some very hard choices. A critical element in our plan to maintain momentum during the Shuttle hiatus is our "Vitality Package". It will provide an infusion of research funds to support university research and continue to promote the space sciences to graduate students as a viable research option during the hiatus of flight opportunities. The research will focus on two areas that desperately need attention: increased attention to the suborbital program as the only current source of flight opportunities and the continuation of basic research and data analysis from previous flight missions. This package provides for the reallocation of funds from the baseline program in order to maintain vitality for the university research community. It will provide immediate research opportunities, and is directed to the shorter range needs pending the resumption of normal payload development and flight opportunities. Vitality funds do not initiate major long-term obligations. I will talk about our plans and the program funding requirements in a minute. Before doing so, however, I'd like to highlight several of our major achievements during the past year.

## HIGHLIGHTS

### Voyager 2 Encounter with Uranus

On January 25, 1986 the Voyager 2 spacecraft provided our first detailed look at the seventh planet Uranus, nearly 3 billion kilometers from the Sun, a world so distant that it was only discovered through a telescope 200 years ago.

Close up, Uranus turned out to be even more different than we had suspected. Its blue-green atmosphere is almost featureless, and scientists could detect structural details only after careful processing of the imaging data. Over the poles, the atmosphere contains a high haze of methane and shows no structure at all. Single clouds appear only in the clear atmosphere within 45 degrees of the planet's equator. The planet's magnetic field, which is strong, was the biggest surprise. Like the Earth, Uranus has a dipolar field. Unlike the Earth, the axis of the

field is oriented at the remarkably large angle of 60 degrees from the axis of rotation, and the center of the field is offset more than 7,700 kilometers from the center of the planet. As a result, the magnetic field of the rotating planet twists and describes a corkscrew shape on the side of the planet down wind of the Sun.

Voyager 2 photographed the nine known rings that surround Uranus for the first time. The spacecraft also discovered two more rings and provided evidence that several more discontinuous ring arcs also orbit the planet. The ring material is extremely dark, similar to carbon black or soot. The moons of Uranus also provided major surprises. Ten new satellites were discovered; nine of them are much smaller than the five already known Uranian moons. The five larger moons are all dark; their surfaces show much more extensive and varied geological activity than expected. At one end of the spectrum, the moon Umbriel has a uniform dark surface possibly produced by recent blanketing of the moon by dark material. By contrast, Miranda, the smallest of the five, has a complex and totally unique surface--a patchwork of different terrains, including huge icy canyons more than 10 kilometers deep. The Voyager 2 spacecraft continues onward toward an encounter with the planet Neptune in 1989.

## The Return of Halley's Comet

1986 marked the return of Halley's Comet in its 76-year cycle around the Sun. For the first time in its 30 recorded appearances, this famous comet was tracked, observed and measured electronically, not only in the optical band but in various parts of the electromagnetic spectrum, by very sophisticated instruments from the ground, in earth orbit and in deep space.

An international flotilla consisting of spacecraft from the European Space Agency (ESA), the U.S.S.R., and Japan flew close by the comet. U.S. spacecraft, including one in orbit around Venus, also made significant observations of Halley's comet, and the NASA deep space network provided precision tracking for the international flotilla. One thousand scientists from 50 nations participated in the International Halley Watch.

Nearly three dozen U.S. scientists were involved in ESA's Giotto mission, which intercepted Halley's Comet on March 14, 1986, approaching within 600 kilometers of the comet's small nucleus. This very close approach was made possible only by the close cooperation established between NASA, ESA, and the U.S.S.R., under the auspices of the Inter-Agency Consultative Group in tracking and coordinating the various spacecraft missions.

Close-up observations of Halley's Comet from Giotto and other spacecraft discovered that the solid nucleus of the comet is a highly irregular object and much larger than expected. The surface of the nucleus is covered by a layer of black dust the thickness of which is unknown, and the surface temperature, about

330°F, is much higher than predicted. Numerous jets of dust and gas are continuously shot out of fractures in the nucleus, and that activity is limited to the sunlit side of the nucleus.

During March of 1986 the International Cometary Explorer (ICE) was targeted to a point upstream of Halley's Comet by 30 million kilometers at the same time as Halley was being investigated by the five satellites from Europe, Japan, and the U.S.S.R. From this great distance ICE detected energetic ions and plasma waves from Halley's Comet that were consistent with predictions based on the spacecraft's earlier encounter with Comet Giacobini-Zinner in September 1985. In addition, water has been detected in comet Halley. The detection was made by instruments aboard NASA's Kuiper Airborne Observatory (KAO), a C-141 aircraft operated by NASA's Ames Research Center and equipped with a 91-centimeter telescope. KAO observed the comet as it was approaching the Sun in December 1985 and again in March 1986 as the comet began receding from the Sun. This detection is very significant, because water ice is thought to be the most important single component of a comet.

Among the ground-based studies of Halley's Comet, the International Halley Watch (IHW) has been an extremely successful international program of cooperative ground-based astronomical observations. NASA and numerous U.S. scientific institutions have been actively involved in the program, and the Jet Propulsion Laboratory (JPL) in Pasadena, CA serves as one of the two administrative centers. More than 1,000 photographs of the comet have been obtained since 1984, and many IHW results were used to support the operations of the comet intercept missions. Of the more than 1,000 scientists, representing over 50 countries, participating in the IHW, more than one-third are Americans.

Infrared Astronomy Satellite

We continue to see the promise of discovery fulfilled as scientists investigate the nature of the over 250,000 infrared sources detected by the Infrared Astronomy Satellite (IRAS), a NASA-Dutch-British project launched in 1984. In 1986, a team at the University of Arizona discovered that one of the IRAS infrared sources is a young protostar--a large mass of gas and dust collapsing rapidly under the force of its own gravitation to become a star. The observations were made with ground-based telescopes directed toward promising candidates found in the IRAS catalog. Because this is the first time we have been able to see a star being born, the discovery is very significant. There are many theories on the subject, but this is the first time astronomers have a specific object on which to test them. We expect this object to be a rich source of information about how stars and planets form, especially once astronomers can resume infrared observations from space.

Satellite-Aided Search and Rescue System

COSPAS/SARSAT, the international satellite aided search and rescue program, began as an outgrowth of NASA activities. It evolved into a cooperative program among the U.S., the Soviet Union, Canada, and France and has been recently expanded to include participation by Norway, the United Kingdom, Bulgaria, Finland and Denmark. In 1986, Chile and Brazil also proposed to join the program. The system which recently completed its first year of regular operation, has already been credited with saving more than 675 lives throughout the world. This success has stimulated the participating governments to draft a new agreement to reflect their commitment to the program. Also significant was the endorsement of 406 MHz proposed by NASA as the primary frequency for the proposed Emergency Position Indicating Radio Beacon for the Future Global Maritime Distress and Safety System. Work is continuing to develop world-wide standards for the Emergency Locator Transmitters operating in the same frequency band.

Monitoring the Ozone Hole

Ozone acts as a protective shield to absorb damaging radiation from the Sun. The apparent deterioration of the ozone layer in Earth's upper atmosphere is a major concern to scientists, particularly in light of observations over the past several decades that indicate that the composition of the Earth's atmosphere is changing. These observations show that the amount of ozone in the atmosphere has been fluctuating, particularly over Antarctica. To investigate this phenomena, a group of scientists, cosponsored by NASA, the National Oceanographic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), and the Chemical Manufacturers Association (CMA) conducted an expedition to Antarctica last year. Using balloon-borne instrumentation and remote sensing techniques, they studied the ozone deterioration which had been observed. The results of this expedition will help to identify the cause of ozone breakdown, and to determine whether the change over Antarctica is a precursor of changes elsewhere on the globe. In 1986, NASA completed a comprehensive report on the current state of understanding of the distribution of atmospheric ozone and susceptibility to change through natural and man-made causes. The assessment, cosponsored by NOAA, the World Meteorological Organization, the United Nations Environment Program, the Commission of the European Communities, and the Federal Republic of Germany will provide the basic data needed to advance important investigations in this critical area.

NOAA-G Weather Satellite Launch

The September, 1986 launch of the NOAA-G weather satellite on an Atlas expendable launch vehicle was picture perfect, with smooth operations and no delays through liftoff. After all systems were fully checked out and determined to be functioning properly, the

spacecraft was turned over to NOAA for routine operations early in December. Now designated NOAA-10, it is providing daily global coverage in the early morning orbit.

BUDGET SUMMARY

The budget request I present today represents the level needed to carry us through the hiatus of Shuttle availability, maintain program momentum, and continue our major programs in a state of readiness for the resumption of flight.

The total FY 1988 Research and Development request for the Office of Space Science and Applications (OSSA) is $1508.3 million. This funding level will support a balanced program in the various disciplines of space science and applications and will also provide funding for the "Vitality Package" needed to sustain a healthy research base through the Shuttle flight hiatus.

This request provides funding for a proposed new start, the Global Geospace Science (GGS) program, which will build on the Collaborative Solar-Terrestrial Research Program initiated in 1987 as a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Astronautical Science (ISAS). Two new U.S. missions, Wind and Polar, will be combined with the Japanese Geotail mission and the Combined Release and Radiation Effects Satellite (CRRES) to make coordinated measurements and obtain the first comprehensive, multi-point study of global magnetospheric response to solar wind. These missions, along with ESA's contribution, SOHO and Cluster, make up the International Solar-Terrestrial Physics (ISTP) program. GGS will provide a major advance in our understanding of solar-terrestrial physics and will assure a key role for the U.S. in this important field.

This budget will maintain the critical momentum needed to carry the Space Science and Applications Program through the hiatus of flight opportunities, and to be prepared to move forward when Shuttle flights resume. It will support the testing and certification of the Hubble Space Telescope, the centerpiece of the space science program. It will support the Galileo mission to Jupiter and the Ulysses mission which will provide our first view of the Sun and solar system from above the ecliptic plane. It will support the Ocean Topography Experiment (TOPEX) which will give global coverage of ocean surface currents and measure them with high precision and accuracy over long periods of time. It will continue development on other exciting and important programs, including the Gamma Ray Observatory, the Magellan mission to Venus, the Upper Atmosphere Research Satellite and the Mars Observer. It will support critical activities in Life Sciences and additional effort in the Microgravity Science and Applications disciplines as well as planning for the utilization of the Space Station.

The budget will also support the continuation of the Explorer

program, and the activities necessary to maintain readiness of Spacelab and other Space Shuttle Payload missions when flights resume. It will also support our development work on instruments and facilities for early use of the Space Station, and provide the funds needed to implement the Vitality Package to make maximum use of our broad-based research and analysis capability.

Consistent with Administration policy that the development of commercially oriented technology should be left to the private sector, we are not requesting FY 1988 funds for the Advanced Communications Technology Satellite.

The FY 1988 budget request for Science and Applications will maintain a strong program through the Shuttle flight hiatus, and ensure our readiness to implement our approved missions as soon as practically possible. The details of the FY 1988 budget request are displayed on Charts 1 and 2. I will now briefly review some of the major elements of the program.

PHYSICS AND ASTRONOMY

In FY 1988, we request $567.1 million for our Physics and Astronomy program, which includes Spacelab, Astrophysics, Explorer, and Suborbital activities.

In the Astrophysics program, NASA is poised to bring the world a whole new look at the universe around us. Discoveries continue to be made using the results of IRAS and the High Energy Astronomy Observatories (HEAO) and from new observations with the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM). But a new age of understanding will begin when we launch the first two of the Great Observatories in space--the Hubble Space Telescope (HST) and the Gamma Ray Observatory (GRO). By the time we complete the Great Observatory program with the Advanced X-ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF), astronomers will have for the first time the ability to simultaneously observe the universe with high sensitivity over the entire electromagnetic spectrum. They will be able to investigate the secrets of the universe unhindered by the distorting and absorbing atmosphere that blocks all frequencies except the information carried by visible light and radio waves. We eagerly anticipate this coming era of great scientific achievement.

The Great Observatories are complemented by smaller Explorer and Spacelab missions that investigate special problems in astrophysics such as performing the first surveys of the sky at wavelengths accessible only from space. Finally, the entire flight program stands on a scientific and technical base developed by our supporting programs of Suborbital flight and Research and Analysis.

Hubble Space Telescope

The Hubble Space Telescope (HST), originally scheduled for launch in the fall of 1986, is now expected to be launched in the summer or fall of 1988. We still regard it as potentially the most significant tool for scientific discovery in our lifetime.

For FY 1988, we request $98.4 million for development activities to prepare for launch readiness and $93.7 million for preparations for on-orbit operations and maintenance of the HST. Our forecast that the HST will provide a major leap in sensitivity, resolution and precision in astronomical observations has now been supported by extensive ground testing of the entire observatory system. By the summer of 1986 HST had completed an extensive, rigorous and realistic series of tests, including a thermal-vacuum test, which simulated the actual environment of space. Concurrently, the ground system control, communications and science data return were exhaustively tested. The test results provided convincing evidence that the HST observatory will meet or exceed the original performance objectives. The pace of post-test and pre-ship activities has been reduced in keeping with the adjusted launch schedule. A period of active storage during spring and summer of 1987 will be followed by the confidence tests, pre-ship tests, shipment to Kennedy Space Center (KSC), and launch. The ground elements of HST are launch ready, but will undergo further enhancements previously scheduled for the post-launch period. In addition, further operating tests are being conducted to calibrate and standardize their functions. Plans for servicing are well advanced, and procurement of hardware items are in progress to support servicing on orbit after launch of the HST spacecraft.

Gamma Ray Observatory

For FY 1988, we request $49.1 million to begin integration and testing of the complete observatory. When it is launched in 1990, the Gamma Ray Observatory (GRO) will present to astronomers a dramatic improvement in sensitivity and resolution for observations of gamma rays emitted by such violently active objects as quasars, pulsars, and black holes. The least energetic phenomena to be observed by GRO are remote nuclear processes and regions where the temperature reaches a billion degrees; at the most energetic, the gamma rays observed by GRO will tell us about subatomic collisions in space that are 100,000 times more energetic still. Development and testing of instruments continues and assembly of the spacecraft structure will be completed in FY 1987.

Explorer Program

We request $60.3 million to continue the definition and development of the relatively small and complementary missions of our Explorer series, which have yielded so many important scientific results.



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The Cosmic Background Explorer (COBE) is now being planned for launch in 1989 to seek new knowledge about the earliest observable stages in the evolution of the universe. COBE's cryogenically cooled instruments will search in the spectral region from the near-infrared to microwave frequencies making an all-sky map of the diffuse cosmic background radiation and measuring the spectrum with great precision. During 1986 COBE's two cryogenically cooled instruments, the Diffuse Infrared Background Experiment (DIRBE) and Far Infrared Spectrometer (FIRAS), were successfully tested in a dewar at a few degrees above absolute zero. The mission requires a nearly polar orbit, and we have begun modifying COBE for launch on a Delta vehicle from the Western Test Range.

The Extreme Ultraviolet Explorer (EUVE) will conduct the first high-sensitivity survey in a wavelength band between ultraviolet light and X-rays, and it will perform spectroscopic investigations of selected sources as well. The EUVE payload is under development at the University of California at Berkeley in preparation for a Critical Design Review in 1987. Final testing is planned for 1988. The X-Ray Timing Explorer (XTE) will extract information about neutron stars and black holes from fluctuations in the intensity of the x-rays they produce. In 1987, work will continue on XTE instrument technology and systems definition.

The Roentgen Satellite (ROSAT) is a cooperative program involving the United States, the Federal Republic of Germany (FRG), and the United Kingdom (UK) to make a full-sky survey in the X-ray portion of the spectrum. The FRG is building the spacecraft, a focusing X-ray telescope and two of the three planned focal plane instruments. The United States is supplying the launch and the third focal plane instrument, a High Resolution Imager (HRI). The HRI is due to be shipped to Germany early in 1987 for integration and testing. Other 1987 activities will concentrate on preparing the U.S. ROSAT Science Data Center at the Goddard Space Flight Center for operation.

In 1986, NASA selected United States investigators to work as part of a U.S./Japanese team to develop a soft x-ray telescope for the Japanese SOLAR-A mission. The Japanese plan to develop the other major instrument and launch their mission to study solar activity in 1992.

Mission Operations and Data Analysis

The FY 1988 request of $128.1 million will support preparations for launch, operation and future maintenance of the Hubble Space Telescope (HST), continued operations and data analysis support for the Solar Maximum Mission (SMM) and International Ultraviolet Explorer (IUE), and the analysis of data from the Infrared Astronomical Satellite (IRAS) and the High Energy Astronomy Observatories (HEAO).

The Solar Maximum Mission (SMM) is returning excellent data on the Sun during the transition from one solar cycle to the next. Solar activity reaches a peak of intensity every eleven years, and SMM has been observing this activity since the last peak in 1980. Activity on the Sun is now at its lowest level, but it will soon begin building up toward another peak in 1991. After being repaired during a Space Shuttle mission in 1984, SMM continues to return data despite a failure of a Tracking and Data Relay Satellite System (TDRSS) antenna in February 1986, when it locked up during a maneuver to view comet Halley. Solar data continue to be sent directly to Earth via the S-band antenna.

The International Ultraviolet Explorer (IUE) is a joint project with the United Kingdom and European Space Agency (ESA). Although designed for only a three-year operational life, IUE is now completing its eighth year of continuous operation. The spacecraft's 18-inch telescope played a major supporting role during the international observations of comet Halley by providing the long-range reconnaissance to enable spacecraft from ESA, Japan, and the Soviet Union to make direct measurements of the comet as it passed away from the Sun. More than a thousand American astronomers have used IUE, and requests for observing time continue to rise. More than 200 new proposals were received last year from scientists in half of the United States and several foreign countries. Interest remains high, as we have received another 319 proposals for FY 1988.

The Infrared Astronomy Satellite (IRAS), a joint program with the Netherlands and the United Kingdom which made the first infrared, all-sky survey in 1983, continues to be a source of important discoveries as the data are analyzed. In a vigorous program of research, IRAS data are being provided to scientists from around the world by the Infrared Processing and Analysis Center at the Jet Propulsion Laboratory.

During 1986, data from the High Energy Astronomy Observatories (HEAO-1, 2 and 3) continued to provide significant contributions to our understanding of the universe as revealed through high energy astrophysical processes. Continued analysis of the HEAO-2 data on clusters of galaxies, for example, has revealed the presence of x-ray emissions indicative of a large inflow of matter (approximately one thousand solar masses per year) into one such cluster. This observation of the formation of a galaxy in progress was largely unanticipated in most theories, which predicted that galaxy formation had occurred only during the very earliest epoch of the formation of the Universe.

This year, we have begun a new, coordinated, archival research program to encourage maximum use of the valuable data sets collected by our astronomical missions. In addition to analyzing data from the archives of HEAO, IRAS, SMM, and IUE, scientists can also propose to make investigations using data from the European EXOSAT mission. Early indications from the scientific

community shows that interest in the Space Astrophysics Data Analysis Program is very high. This effort will be continued in FY 1988. Such a coordinated data analysis program is one example of use of the "Vitality Package" allocation.

PLANETARY EXPLORATION

The FY 1988 budget request for Planetary Exploration is $307.3 million. This amount includes funds for continued development of several missions: the Galileo orbiter/probe to Jupiter, the Ulysses mission to explore the poles of the Sun, Magellan (formerly the Venus Radar Mapper), and the Mars Observer. It also includes funds for the operation of existing spacecraft, supporting activities, and ground-based research.

Galileo

In FY 1988, we are requesting $55.3 million for continued development of the Galileo mission, a joint project between NASA and the Federal Republic of Germany (FRG). This mission is planned to make a comprehensive, long-term study of the giant planet Jupiter, its atmosphere, huge magnetic field, and large and unusual moons. The spacecraft has two parts: an Orbiter to make the long-term surveys and a Probe that will enter Jupiter's atmosphere and make direct analyses of its composition.

Galileo was ready for launch in May 1986 on a Shuttle/Centaur combination. The Challenger accident in January, 1986 forced a postponement of the launch. The subsequent cancellation of the Shuttle/Centaur upper stage because of Shuttle safety concerns forced a further re-evaluation of the mission because no other available upper stage is powerful enough to insert Galileo into a direct Earth-Jupiter trajectory.

Present plans call for Galileo to be launched with a Shuttle/Inertial Upper Stage (IUS) combination on an initial trajectory toward a Venus swingby, followed by two Earth swingbys, using the three gravitational assists to obtain the energy required for a trajectory to Jupiter.

During 1986 a significant effort was made to study various launch and trajectory possibilities, leading to the one currently planned. Studies were also conducted to determine the changes that need to be made to the spacecraft in order for it to fly the new trajectories. These changes are chiefly in thermal control design because the spacecraft, in passing Venus, will be going closer to the Sun than originally planned. During 1987 these thermal control changes will be implemented; in addition, certain changes will be made to improve the reliability of the spacecraft computers. These changes will be tested during 1988 to assure that the spacecraft will perform properly on its new mission profile.

Ulysses (Solar Polar Mission)

In FY 1988, we are requesting $10.8 million for continued development of the Ulysses mission, a cooperative effort between NASA and the European Space Agency (ESA). Ulysses will provide our first view of the Sun and the solar system from above the ecliptic plane.

By observing the Sun and its surroundings from a wide range of solar latitudes, Ulysses will make detailed observations of the structure of the Sun's magnetic field and the nature of the streams of atomic particles ejected from the Sun in solar wind and solar flare eruptions. These data will provide previously unavailable fundamental data about the Sun and will help us to better understand the effects of the Sun's activity on the Earth's weather and climate.

The Ulysses launch on board a Shuttle/Centaur was originally scheduled for May, 1986. It has been postponed due to the Challenger disaster and the subsequent cancellation of the Centaur upper stage. Current plans now call for launching Ulysses in either September 1989 or October 1990, using the Shuttle and IUS/PAM-S launch stages. The final decision on the launch date will be coordinated with our European partners.

During 1986, spacecraft pre-launch testing at the Kennedy Space Center (KSC) was completed and the spacecraft was returned to ESA for storage. The science instruments were returned to the investigators for storage and periodic checkout. Mission design efforts were initiated to support the new mission profile and launch dates. During 1987, as the launch date becomes more definite, this effort will concentrate on details of the new launch, the interplanetary trajectory, and mission operations planning. Activities will also continue to make the spacecraft compatible with the new launch vehicles. In 1988, activities will focus on completion of the new spacecraft/launch vehicle documentation, launch approval activities involving the Radioisotope Thermoelectric Generator (RTG), and the plans for retesting the spacecraft and the science instruments.

Magellan (Venus Radar Mapper)

FY 1988 funds of $59.6 million are requested to continue development of the Magellan mission. This spacecraft will map the surface of the planet Venus from orbit, using a radar instrument to penetrate the thick, permanent clouds that hide the planet's surface. The radar images will provide essential data on the planet's geology, topography, structure, and evolution, so that we can begin to understand Venus as well as we now do Mars, Moon, and Earth.

Magellan is currently planned for launch in April, 1989, on a Shuttle/Inertial Upper Stage (IUS) vehicle. After reaching Venus in July 1989, Magellan will map the major portion of the entire

planet during a period of eight months, with a ground resolution of about 150 meters.

During 1986, the mission was readjusted to accommodate a one-year delay caused by the Challenger accident and cancellation of the originally planned Centaur upper stage. Progress was made in completing and testing the development model of the radar. Considerable progress was also made in the build-up of the structure and subsystems for the flight spacecraft.

In 1987 the flight model of the radar instrument will be built, tested, and delivered. The flight spacecraft will be assembled, and the radar system and the subsystems will be integrated and undergo initial environmental tests. Final design reviews will be held for mission design and mission operations for the 1989 launch opportunity. In 1988, all efforts on the flight spacecraft will be completed, and it will be shipped to KSC for launch preparations.

Mars Observer

In FY 1988, $29.3 million is requested to support continued development of the Mars Observer mission, which was approved as a new start in FY 1985 as the first in a series of Planetary Observer missions to explore the inner solar system. The mission, planned for launch in 1992, will place a remote-sensing spacecraft in a near-polar orbit around Mars, from which it will determine the planet's surface composition, atmospheric composition and dynamics, topography, magnetic and gravitational fields, and other global characteristics over a full Martian year (about two Earth-years).

During 1986, RCA was selected as the contractor for the Mars Observer spacecraft; and the Preliminary Design Review was completed. The prime contractor for the upper stage launch vehicle was also selected: Orbital Sciences Corp. Their major contractor is Martin Marietta. Development activities for the upper stage are well underway at both institutions. Another important milestone last year was the selection of an excellent group of science investigations, including an imaging system; accommodation reviews have been completed with all the experimenters.

During 1987 final confirmation of the science investigation payload will be completed, and the spacecraft Critical Design Review will be held. A Preliminary Design Review for the Mission Operations System has been conducted. In 1987 and 1988, the scientific content of the mission will be expanded by the selection of a group of Participating Scientists to complement the instrument-oriented investigations already selected.

Mission Operations and Data Analysis

The FY 1988 request of $77.0 million will support five major

operating spacecraft: Voyager 1 and 2, Pioneer 10 and 11, and the Pioneer Venus Orbiter. Minor support is also provided for four other operating spacecraft: Pioneer 6, 7, 8, and 9.

Voyager Program. Voyager 1 and 2 continue to explore the outer solar system, outward bound on trajectories that will take them into interstellar space. Voyager 1, launched on September 5, 1977 is well past the orbit of Uranus and continuing to climb out of the plane of the solar system. From this unique path, it continues to send information about the nature of interplanetary space in that distant part of the solar system.

In January, 1986 Voyager 2 (launched on August 20, 1977) became the first spacecraft to fly past Uranus. In this encounter, the spacecraft transmitted more than 7,000 images of the planet, its rings, and moons, together with a large amount of other planetary data. Voyager 2 is now headed for its final planetary destination, the eighth planet Neptune, more than 4.5 billion kilometers from the Sun. Arriving at Neptune in August 1989, Voyager 2 will provide the first close-up study of Neptune and its giant moon Triton.

Pioneer Program. Pioneer 10 (launched in 1972) and Pioneer 11 (launched in 1973), both continue on their way outward bound into interstellar space, exploring the interplanetary medium in the outermost parts of the solar system. Their primary goal is to define the heliopause, the boundary between the Sun's magnetic field and true interstellar space. Pioneer 10 is now about 38 astronomical units from the Sun. Pioneer 11, traveling in the opposite direction, is now between the orbits of Uranus and Neptune. Pioneer 11 played an invaluable role in Voyager 2's encounter with Uranus by monitoring the solar wind during the encounter.

Pioneer Venus Orbiter (PVO), launched in 1978, continues to return data from orbit around Venus. In early 1986, the spacecraft successfully carried out unique observations of Comet Halley when the comet was "behind" the Sun as seen from Earth. The spacecraft's Ultraviolet Spectrometer made daily observations of the comet's behavior during its most active period, obtaining data on the comet's chemical composition and its rate of water loss. The same instrument also mapped a huge cloud of hydrogen gas, more than 20 million kilometers in diameter (15 times as large as the Sun!) which forms the outer layer of the comet's coma. Observed changes in the shape and brightness of this hydrogen cloud provides evidence of varying pressure of solar radiation against it.

As the orbit of PVO around Venus slowly changed, other instruments made important new measurements of the comet-like interaction of the solar wind with Venus itself, providing a range of coverage at new planetary latitudes. The data gathered in 1986 are especially important because of the minimum solar activity going on at that time.

The orbit of PVO is gradually decaying as a result of atmospheric drag, and in 1992 the spacecraft will finally enter Venus' atmosphere and burn up.

Flight Mission Support. In 1986 the Mission Control and Computing Center (MCCC) under the direction of the Jet Propulsion Laboratory's Flight Project Support Office, successfully supported the Voyager 2 encounter of Uranus. The unique data from this encounter was obtained almost flawlessly in both real-time and batch processing modes and was rapidly analyzed by the new Multi-mission Imaging Processing Laboratory (MIPL) to produce the striking and scientifically important images of Uranus, its rings, and surprising moons. The MCCC also successfully supported the Giotto encounter with Halley's Comet, as well as the observations of the comet by the Pioneer Venus Orbiter spacecraft.

In addition to supporting encounter missions, the MCCC also completed the Ground Data Systems testing for the previously planned May 1986 launch of the Galileo and Ulysses missions. Significant advances were also made in designing the new Space Flight Operations Center (SFOC) by using a prototype facility. The SFOC is being designed to provide a multi-mission ground data system capability that will be both cost-effective and scientifically productive.

During 1987 and 1988, the design for the development of the SFOC baseline facility will be completed, and the existing prototype facility will be adapted to support the Magellan mission, now planned for launch to Venus in April, 1989. Work will also begin on the further modifications needed to support the continued operation of the Voyager missions, the delayed launches of Galileo and Ulysses, and the Mars Observer mission.

Research and Analysis

Ground-based telescopic studies were conducted in 1986 and 1987 to support the Voyager 2 encounter with Uranus, the ESA and U.S.S.R. encounters with Comet Halley, and to prepare for the Voyager 2 encounter with Neptune in 1989. The Comet Halley observations were especially important in providing targeting information for the ESA Giotto and the U.S.S.R. VEGA spacecraft.

Other support was provided through a number of diverse planetary science research programs involving planetary geosciences, planetary atmospheres, and the study of such extraterrestrial materials as lunar samples and meteorites. In particular, continuing scientific studies of Venus, using data from the U.S.S.R. spacecraft, and of Mars, using Viking data, are providing the critical scientific baseline for the forthcoming Magellan and Mars Observer missions to Venus and Mars respectively.

In addition, substantial progress was made in developing the Planetary Data System (PDS), a system which will assure the acquisition, care, and analysis of both past and future planetary mission data sets. Finally, the effectiveness of the recently-begun Planetary Instrument Definition and Development Program (PIDDP) was demonstrated in 1986 when nine instruments, all developed or improved during that program, were selected as parts of the payloads for the planned Mars Observer mission and unapproved Comet Rendezvous/Asteroid Flyby (CRAF) missions.

These research activities will continue in FY 1988, with several special goals: to upgrade the Planetary Data System by establishing five remote discipline-oriented computer nodes, to prepare for the Voyager 2 encounter with Neptune, and to support the Magellan and Mars Observer missions, now scheduled for launch in 1989 and 1992 respectively. In addition, analysis of data obtained at Uranus by Voyager 2 and a wide range of fundamental research on solar system properties and evolution will continue, and the development of new instruments will be undertaken to meet future flight opportunities.

EARTH SCIENCE AND APPLICATIONS

In FY 1988, $470.6 million is requested to support the Earth Science and Applications programs identified under the categories of Solid Earth Observations and Environmental Observations. The request will also support an exciting and important new start, the Global Geospace Science (GGS) mission.

Global Geospace Science (GGS)

We are requesting $25.0 million in FY 1988 to develop two new spaceflight missions, Wind and Polar, as part of a comprehensive science program to measure, model and understand the solar influence on the Earth's neighborhood called Geospace. This influence is to be measured by the Wind and the Polar spacecraft in conjunction with the Japanese Geotail mission. From these measurements, quantitative models will trace the energetic plasma particles and fields in the solar wind through acceleration and storage in the Earth's magnetosphere to the ultimate deposition in the Earth's atmosphere. In the polar regions, this energy deposition equals the solar radiant energy input and therefore has a significant influence on the atmospheric energy balance. From the GGS results, predictions of disruptive effects on the ground and in space will be more quantitative as we will better understand the dynamics of the Geospace system. GGS is the major U.S. contribution to the International Solar-Terrestrial Physics (ISTP) program planned together with the Japanese Institute of Space and Astronautical Sciences (ISAS) and the European Space Agency (ESA). It will help maintain a key U.S. role in solar-terrestrial research by involving more than 200 scientists from 17 U.S. Universities, 3 NASA Field Centers, 7 Research Laboratories and 14 Foreign Countries. The ISTP program also includes the complementary Collaborative Solar-Terrestrial

Research initiative approved in the FY 1987 budget for U.S. instruments on ISAS's Geotail and ESA's SOHO and Cluster missions to monitor long term variability of the sun, investigate the origin of the solar wind, and reveal the nature of universal plasma processes that are found within Geospace.

Upper Atmosphere Research Satellite (UARS)

We request $95.4 million to continue development of the UARS observatory which was approved as a new start in FY 1985. The UARS program is directly responsive to NASA's mandate to develop and implement a comprehensive program of research, technology, and monitoring of atmospheric phenomena. Instrument development began for the UARS payload in 1982 to develop the complex, remote-sensing instruments that pace the UARS program. As a result of the Challenger accident, the launch of the UARS observatory has been rescheduled from 1989 to late 1991. UARS will be the first satellite capable of simultaneous measurement of energy input, chemical composition, temperature and winds of the upper atmosphere, including the ozone level. In 1986 all but one of the ten UARS instruments successfully completed their Critical Design Review and development of the observatory continued. In 1987 flight instrument assembly will be completed and testing will begin. Also, Preliminary Design Reviews will be held for the observatory and Central Data Handling Facility (CDHF). In 1988 Critical Design Reviews will be held for the observatory and CDHF and four instruments will be delivered. Instrument deliveries, including one British and one Canadian-French instrument, will be completed in 1989 and integration and test will begin. Software for data processing and interpretation will be delivered by the Principal Investigator teams in 1989.

Ocean Topography Experiment (TOPEX)

FY 1988 funds of $90.0 million are requested to continue development of the TOPEX mission. TOPEX will use an advanced radar altimeter and tracking system to measure the surface topography of the oceans, from which information on ocean circulation can be determined. TOPEX is planned as a joint mission by NASA and the French Space Agency (CNES). The CNES contribution includes an Ariane launch for NASA's TOPEX satellite and provision of French instruments. Scheduled for launch in late 1991, a three year mission is planned. In 1987 a satellite contractor and a science team will be selected, and sensor and ground data system development will begin. In 1988 we will conduct a Preliminary Requirements Review (PRR) and continue developing satellite and ground data systems. Sensor development will continue through Critical Design Review leading to actual construction by late 1988. The science team will also refine research plans and design options.

NASA Scatterometer (NSCAT)

The FY 1988 budget request includes $22.7 million to continue development of the NASA Scatterometer (NSCAT), a radar system which was planned to be flown on the U.S. Navy Remote Ocean Sensing Survey (N-ROSS) satellite in 1990. Since the Navy has announced the cancellation of N-ROSS, we are studying alternatives to accommodate the critical NSCAT mission in the TOPEX timeframe. The most viable of these appear to be the Air Force Defense Meteorological Satellite Program (DMSP), the Space Test Program (STP), or TOPEX. The Air Force options are being studied at the joint request of the Navy and NASA (Air Force was an N-ROSS partner) so as to continue the critical elements of N-ROSS. The FY 1988 budget request would support launch of NSCAT and DMSP in late 1990 should a decision be made to adopt that approach.

NSCAT is designed to make accurate measurements of the surface wind over the oceans. It will provide a capability to undertake the first global study of the variability of marine winds. In concert with TOPEX, it will enable an understanding of how atmospheric winds drive the circulation of the world oceans. Continued development of the Alaska Synthetic Aperture Radar Facility (ASF) is included in the NSCAT request. The ASF will be equipped to receive, process, analyze, and archive SAR data from the first European Remote Sensing satellite (ERS-1), under an agreement with ESA, which has a planned launch date of early 1990. By this time the ASF will be capable of producing high resolution images of Alaska, portions of northwest Canada, and the oceans surrounding Alaska from data relayed to ASF from the ERS-1. NASA also plans, subject to agreement with Japan, to receive SAR data at the ASF from Japan's Earth Resources Satellite (JERS-1) which is planned for an early 1991 launch. In 1987 various hardware components will be delivered, construction of the radio frequency subsystem started and a Critical Design Review held. FY 1988 plans include continued hardware development, testing and integration of the flight hardware, delivery of the second computer system, and continued refinement of post-launch research and verification.

Solid Earth Observations and Environmental Observations Payloads and Instrument Development

The FY 1988 budget request contains $43.6 million for continued development of Earth Science and Applications Shuttle and Satellite Payloads. These include the Tether Satellite System, and reflight of some instruments previously flown on the Shuttle, for example, Measurement of Air Pollution from Space (MAPS), Atmospheric Trace Molecule Spectroscopy (ATMOS), Feature Identification and Location Experiment (FILE), and Active Cavity Radiometer (ACR-1).

To prepare for reflight of these instruments, refurbishments and modifications will be needed, followed by reflight

qualifications. Instruments such as ATMOS will conduct important ground observation programs; others will be placed in storage with periodic planned calibration checks. Data processing, analysis and archiving from the previous missions continue, as well as aircraft flights for correlative measurements and shuttle mission simulations to aid in instrument interface verification for Shuttle mission planning.

We will continue to define, design, and construct advanced instruments such as the Shuttle Imaging Radar-C (SIR-C), the Shuttle Imaging Spectrometer Experiment (SISEX), and the Shuttle Light Intensity Detection and Ranging (LIDAR) instrument for global measurements of clouds and atmospheric aerosols.

Mission Operations and Data Analysis

In FY 1988, $26.8 million is requested for Earth Science and Applications Mission Operations and Data Analysis to support operations and the processing, validation, and analysis of data from currently orbiting spacecraft. Nimbus, Solar Mesospheric Explorer (SME), and Earth Radiation Budget Experiment (ERBE) satellites continue to provide valuable information about the atmosphere and oceans. Also, operations, data analysis and scientific interpretation continue among fifty Principal Investigator teams associated with the Space Plasma Physics operating satellites: the Interplanetary Monitoring Platform (IMP-8), the International Sun-Earth Explorers (ISEE-1 & 2), the International Cometary Explorer (ICE), the Dynamics Explorer (DE-1), and the Charge Composition Explorer (CCE). In September, 1986, the third, and final set of the ERBE measurement system was launched into orbit aboard NOAA-10, and is now operating as designed. During FY 1988, ERBE data production processing will commence as the validation phase nears completion. Correlative measurements collected by rockets, balloons, and aircraft flights, will continue to support NASA's earth atmosphere science, including results from ozone instruments aboard NOAA satellites.

NASA Aircraft Facilities

Refitting of the DC-8 acquired to replace the Convair 990 (destroyed in a runway accident in the summer of 1985) is progressing rapidly, and replacement of the Aircraft Quad-Polarization Synthetic Aperture Radar (SAR) will be partially completed by the end of 1987. We anticipate that the DC-8 may be flown to the Antarctic in late 1987/early 1988, to study the springtime depletion of stratospheric ozone that occurs there. The construction of a new aircraft instrument, the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS) to be mounted on a NASA ER-2 jet, is scheduled for engineering flights in February 1987 and scientific test and calibration by April 1987. It will acquire multi-channel spectral data at high spatial and spectral resolution to provide data for detailed mapping of the composition of surface materials. AVIRIS is

expected to be operational for scientific data collection in the summer of 1987.

LIFE SCIENCES

In FY 1988, we are requesting $74.6 million for the Life Sciences Program, which is involved in nearly all aspects of space exploration, ranging from studies of the ability of humans to live and work in space to studies which examine the origin, evolution, and distribution of life in the universe. Last year we established a Task Force under the Chairmanship of Dr. Frederick Robbins, a Nobel Prize Laureate, to develop a strategic plan for Space Life Sciences.

While inflight research opportunities in 1986 were limited by the Challenger accident, a major investigation in neurophysiology was conducted by a U.S.-led team on the German D-1 Spacelab mission. This study clearly demonstrated the alterations in man's visual and vestibular interactions which occur during space flight. International cooperation emerged as one of our major activities during FY 1986. Formal Joint Life Sciences Program Working Groups were established with the European Space Agency, the Japanese, French, and Germans. These groups were organized to use the limited resources available to conduct space research in an efficient way to improve the science return in the Life Sciences and to allow the early formation of international scientific teams to address research problems during the space station era.

The FY 1988 budget request will support preparations for the Spacelab Life Sciences 1 (SLS-1) scheduled for launch during 1990. It will also support preparations for the first International Microgravity Laboratory (IML-1) mission, the Spacelab J mission with Japan, and the second dedicated Life Sciences Spacelab mission, Spacelab Life Sciences 2 (SLS-2). We will also continue to plan a research program for utilization of the Space Station, which will provide facilities for significant research in all areas of Life Science, particularly the investigation of continued and repeated long-term human exposure to the space environment.

NASA is continuing to investigate the nature and mechanisms of human physiological adaptation and deconditioning which occur during space flight. A Health Maintenance Facility, incorporating state-of-the-art technology, is being developed for the Space Station era. A new project concerned with the application of remote sensing technology to the solution of global health problems is being initiated. Definition of space station related facilities required for the wide range of life sciences activities is continuing.

SPACELAB PAYLOADS

Some significant Spacelab payload flight activities took place

prior to the Challenger accident. In October 1985 Spacelab D-1, a reimbursable mission sponsored by the Federal Republic of Germany, which included several cooperative U.S. experiments and the Materials Science Laboratory (MSL) were successfully flown. Considerable progress was made on the analysis of scientific data from the Spacelab-2 and 3 missions in the fields of astronomy, solar physics, plasma physics, biology, materials processing, and atmospheric sciences.

However, the rest of 1986 was dominated by replanning and program streamlining activities in response to the Challenger accident. All planned Spacelab missions have been delayed an average of 3-4 years. Development and mission planning activities have been re-phased, and project teams have been scaled down accordingly. For FY 1988 we request $75.4 million to support our restructured Spacelab Payloads program. Planning continued for critical science missions as noted below.

Astro-1

The Astro payload will explore the universe by observing and measuring the ultraviolet radiation from celestial objects. Targets selected for Astro missions include planets, stars, star clusters, galaxies, clusters of galaxies, quasars, remnants of exploded stars, clouds of gas and dust, and the interstellar medium. Three instruments make up the Astro payload: the Hopkins Ultraviolet Telescope (HUT), the Ultraviolet Imaging Telescope (UIT), and the University of Wisconsin Ultraviolet Photopolarimetery Experiment (WUPPE). Astro will be flown twice in the early 1990's, with each mission lasting from seven to ten days. The ASTRO mission was scheduled to be launched on the first Shuttle flight after the Challenger and hence is in an advanced stage of readiness for an early flight opportunity when Shuttle flights resume.

Shuttle High Energy Astrophysics Laboratory (SHEAL)

Work has continued on the development of two x-ray astronomy investigations to be flown on the SHEAL mission. One instrument, the Diffuse X-ray Spectrometer, will provide the first high-spectral-resolution survey of the million-degree gas in the space between the stars. The second instrument, the Broad Band X-Ray Telescope, will conduct high-sensitivity, moderate-spectral-resolution observations of a wide variety of cosmic x-ray sources. The first SHEAL mission is presently planned for late 1992.

Spacelab Life Science-1 (SLS-1)

SLS-1 is a high priority mission, which will gather data on the physiological effect of weightlessness on humans. It will provide important baseline data needed to enable long-term human presence in space. SLS-1 is scheduled for launch in December 1989, but an option to launch approximately 6 months earlier is

being maintained.

International Microgravity Laboratory (IML-1)

IML-1, which is now scheduled for launch in April 1990, will include microgravity science and life science investigations involving over 150 scientists in the United States and 10 foreign countries. The IML series is based upon the concept of sharing U.S. and foreign flight hardware when appropriate to perform U.S. science, rather than to purchase or develop a replica for U.S. use.

Atmospheric Laboratory for Applications and Sciences-1 (ATLAS-1)

ATLAS-1 is scheduled for launch in January 1991. ATLAS-1, a partial payload, was derived from reconfiguring the Earth Observations Mission-1/2 and 3 in order to provide a more easily manifested payload. The Atlas-1 payload consists of both U.S. and foreign instruments.

Spacelab J

The Spacelab J mission is a shared-cargo mission with NASDA (Japan). Japan is proceeding with payload hardware development and testing to complete the major development effort in 1988. The NASA portion of the payload has the major development effort scheduled for FY 1988 and FY 1989 with a planned launch in May 1991.

Secondary Payloads

A modest level of development will continue on a number of smaller Shuttle attached missions supporting a variety of disciplines including materials processing, high energy astrophysics, solar physics, and atmospheric sciences. The launch status of these missions will be clarified once the manifesting of secondary payloads is addressed.

Airborne Science and Applications Program

The Airborne Science and Applications program aircraft flights will support various discipline investigations in FY 1988 including continued study of the Antarctica ozone hole. The FY 1988 budget includes initial funding to acquire a new ER-2 high altitude aircraft to replace the two aging U-2C's for which DoD is discontinuing maintenance facilities. The new ER-2 will enhance the science payload capacity over that of the single ER-2 and the two U-2Cs (which will be retired).

MICROGRAVITY SCIENCE AND APPLICATIONS

In FY 1988, we request $45.9 million for Microgravity Science and Applications. The goals of the program are: to conduct basic research on the effects of the reduced gravity environment of

space; to understand the basic phenomena of physics, chemistry, and materials science; to apply the results of this research to develop practical applications; and, to provide for the wide dissemination of experimental results to the U.S. industrial, governmental, and academic communities. The program is structured in six major technical disciplines: metals and alloys, electronic materials, glasses and ceramics, biotechnology, combustion science, and fluid dynamics and transport phenomena.

During 1988, an active ground-based research program will be carried out. Due to the Challenger accident, there will be no flight opportunities in microgravity science and applications for about one year after the STS flights are resumed, seriously hampering our ability to obtain a long duration reduced gravity environment to perform experimental studies. The previously planned program was carefully reviewed to determine how to make the best use of the time and resources available until STS operation is reinitiated. As a result of this assessment, we are taking the following steps: (1) storing flight hardware; (2) slowing down the development of selected new space flight hardware to make its later delivery consistent with projected flight opportunities; and, (3) increasing emphasis on complementary research in ground-based laboratories and in the reduced gravity environments provided in our drop towers and aircraft.

Although we believe we can maintain a viable, high-quality program in the short term with this approach, there is no substitute for performing the required long-duration research in the reduced gravity environment of space. We can only develop the reduced-gravity scientific data base required by the scientific, academic, and industrial communities through an aggressive research program aboard the Space Shuttle and eventually the Space Station.

The program challenge is to optimize the research we can conduct within the flight opportunities provided by the projected Shuttle manifest and devise a strategy to provide increased resources and space flight research opportunities that are necessary. The FY 1988 request will also support a significant increase and acceleration in the design and development of microgravity science and applications payloads for the Space Station.

In FY 1988, Microgravity Science and Applications ground-based research will continue in the universities, the Centers of Excellence, industry, and the NASA Centers.

We fund five Centers of Excellence:

- Institute for Theoretical Physics, University of California, Santa Barbara;
- Bioprocessing and Pharmaceutical Research Center of

Philadelphia, University City Science Center;

- Center for Separation Science, University of Arizona;
- Center for Microgravity Fluid Mechanics and Transport Phenomena, University of Colorado;
- Materials Processing Center, Massachusetts Institute of Technology.

The Center for Microgravity Fluid Mechanics and Transport Phenomena at the University of Colorado was initiated during the past year. The ground-based research program in total and the Centers of Excellence in particular serve as an important focus for new ideas and the dissemination of research opportunities and results.

During the Shuttle flight hiatus, we will encourage the use of the Microgravity Materials Science Laboratory (MMSL) located at the Lewis Research Center in Cleveland. The MMSL was created to provide an opportunity for academic, industry, and Government researchers to try out ideas on flight-type hardware. The reduced-gravity facilities, both ground-based (drop towers and drop tubes) and airborne (aircraft), will be utilized much more aggressively to compensate in part for the lack of space flight opportunities. Unfortunately, the short time duration of reduced gravity provided in these facilities limits the nature and scope of the research that can be conducted.

COMMUNICATIONS

In FY 1988, we request $20.5 million for the communications program. Activities include Technical Consultation, Experiment Coordination and Operations Support, and Research and Analysis. No funding is requested in FY 1988 for the Advanced Communications Technology Satellite (ACTS) Program, because it is the position of the Administration that development of this commercially-oriented technology should be left to the private sector.

Satellite-Aided Search and Rescue (SARSAT)

We request $1.3 million in FY 1988 to support system engineering and to develop new technologies for the Satellite-Aided Search and Rescue (SARSAT) Program. This international search-and-rescue system has already been credited with saving over 675 lives. Five satellites are now in service, two from the U.S. and three from the U.S.S.R. The current ground system consists of six mission control centers in the U.S., Canada, France, Norway, U.S.S.R. and Great Britain. Fourteen local user terminals will be in operation by the end of 1987.

During 1988, an experiment using geostationary satellites for

more nearly instant alert will be completed and the results analyzed. Efforts will continue to improve the cost/performance ratio of emergency beacons.

Technical Consultation and Support Studies

We are requesting $3.4 million in FY 1988 for our Technical Consultation and Support Studies program, which provides the technical basis to develop national and international policies, regulations, and telecommunications standards to assure the orderly growth of both existing and new satellite services.

In 1986, we developed a geostationary orbit arc allotment concept as part of the U.S. preparations for the 1988 Space World Administrative Radio Conference (SWARC). This approach will further U.S. interests in retaining flexibility for U.S. communication satellite networks. During 1987, we will participate in the SWARC for mobile services to secure the new allocations for international mobile satellite operation. In 1988 we will complete work on the geostationary orbit arc allotment planning method and provide key support at the second session of the SWARC, and will continue to develop techniques to maximize use of the limited resources of orbital arc and radio spectrum.

The FY 1988 request will support continued operation of the Applications Technology Satellite (ATS) spacecraft, which continues to provide vital support to the National Science Foundation, NOAA, DOD, DOI, the DEA, a number of universities, and state and local governments, and domestic and international disaster relief organizations. Support is provided through satellite voice and data links for science, education, disaster relief, and communications applications experiments to North and South America, most of the eastern Pacific Ocean, Hawaii, and Antarctica.

Research and Analysis

Our efforts in communications research during FY 1988 will focus on future high risk microwave and optical technology needed to increase the capacity and interconnectivity of future communications satellite systems to provide information services at lower costs to smaller terminals for both fixed and mobile applications. The Mobile Satellite Technology Experiment program will develop, build, and test critical technologies for this new service in cooperation with industry and government agency users. The recent approval by the FCC of frequencies for a domestic mobile satellite service has removed a major roadblock to system implementation. In 1986, we completed our system design studies and initiated hardware development. Field tests of some hardware will be conducted in 1987. In 1988, all prototype components will be completed and field testing of the full mobile terminal will begin.

INFORMATION SYSTEMS

For FY 1988, we are requesting $22.3 million for our multidisciplinary Information Systems program. This program supports Space Science and Applications flight projects and science programs in three ways: (1) by managing major NASA computational resources, (2) by working with discipline programs to establish discipline data centers to help NASA scientists locate, access, and utilize data needed for research, and, (3) by developing the advanced networks and computing technologies needed to efficiently handle the massive amounts of data acquired from successful space missions.

Several major data processing systems used by researchers to make large-scale computations and to test complex scientific models are located at the Goddard Space Flight Center (GSFC). These include the large-scale IBM, CDC, and AMDHAL computers in our Space and Earth Science Computing Center (SESCC). In addition, the program is responsible for the National Space Science Data Center (NSSDC), which is the hub of a nation-wide network for NASA-acquired data. This network ensures the widespread availability of data from NASA's satellites and rocket flights.

In FY 1987, we began implementing a master directory for all NASA-acquired data at the NSSDC, and established nationwide electronic access to catalogs at our distributed discipline data centers. Through our "pilot" data systems program, we develop new capabilities to access and manage data for the oceans, planetary, and climate disciplines. The successful demonstration of networks, optical disks and other technologies in one science discipline facilitates their adaptation by other disciplines and flight missions. Like the NASA Ocean Data System in FY 1986, our Planetary Data System (PDS) has been integrated into its client discipline program. The Planetary Research program will use the PDS as the nucleus for a future planetary data network.

In FY 1988, we will continue to develop improved capabilities to manage and distribute space data. We intend to emphasize improved network access to NASA data, develop common catalogs and data standards, and interdisciplinary data systems for planned Space Station platforms. We will help to develop information systems for long-term interdisciplinary flight missions, which includes integrating widely separated data centers into a unified information network to support interdisciplinary research. Such a unified data management capability will be needed by all Space Science and Applications programs and flight projects in the 1990s, especially for major missions such as the planned Earth Observing System (EOS) mission, if approved.

We will continue in FY 1988 to work with NOAA, USGS, and NSF in areas such as networking and supercomputer applications and will provide technical consultation in key areas, such as Earth science, planetary science, astrophysics, and Space Station studies.

SPACE STATION

The Office of Space Science and Applications (OSSA) plans to be a user of the unique resources offered by both the space and ground elements of the Space Station Program. We visualize the Space Station as a NASA laboratory in space, working with our established ground laboratories, such as the Goddard Space Flight Center and the Jet Propulsion Laboratory. Our interests include in-orbit servicing of on-board experiments and free-flying spacecraft, polar and co-orbiting platforms to conduct major future scientific missions (such as the EOS and AXAF), pressurized modules for microgravity and life sciences research, and facilities for attached payloads. We will also continue to utilize sounding rockets, ELVs, Shuttle, Shuttle/Spacelab, unmanned platforms, and other available systems to support science and applications objectives.

OSSA took several significant steps in 1986 to prepare for the Space Station. An integration function was established to focus activities related to the Space Station. We will continue to develop consolidated plans with the discipline divisions, and provide technical support for the conduct and management of multi-discipline studies related to use of the Space Station.

In 1986 OSSA participated in the Space Station configuration and assembly reassessment study with the Operations Task Force. The reassessment study responded to needs identified within NASA as a result of the Challenger accident; it also addressed Congressional concerns that the Space Station Program provide useful scientific research as early as possible during the flight operations phase. Our efforts focused on identifying possible ways in which experiment facilities in the assembled flight elements could be outfitted to perform useful scientific research prior to the completion of the entire assembly sequence.

To support the Operations Task Force, a Science Operations Task Team was established to develop a science operations concept and plan. Space Station will provide researchers with the capability to conduct experiments in space and from their own ground-based laboratories. This capability, called "telescience", a concept developed by our advisory Task Force on the Scientific Uses of the Space Station (TFSUSS), is a major science operations goal for the Space Station era. We are working on a structure to continue to provide this type of professional consultation from the experts in academia and private industry, probably under the aegis of the NASA Advisory Council.

We also initiated a number of technical studies to assure early science benefits from the Space Station. The Pressurized Volume Utilization study is being conducted to establish a baseline plan for outfitting pressurized modules for maximum use by all user groups and disciplines. Other studies examined issues of contamination, waste disposal and logistics and supply. These

studies will help the science disciplines define parameters of payloads and experiments and understand how they will be influenced by the Space Station environment.

We envision extensive use of the Space Station to further our scientific programs. In Astrophysics the most important capability that the Space Station can provide is the servicing of orbiting spacecraft and instruments. Other priorities include co-orbiting platforms which could be used to complete our program of Great Observatories if approved in a future budget, first with the planned Advanced X-ray Astrophysics Facility (AXAF) and then with the Space Infrared Telescope Facility (SIRTF). Potential attached payloads could include the High Resolution Solar Observatory (HRSO) if approved in a future budget, a Cosmic Ray Nuclei Experiment (CRNE) as a follow-on to the one conducted on the Spacelab 2 mission in 1985, and low-cost Spartan payloads similar to those launched and retrieved during Space Shuttle missions.

In the Earth Sciences, a yet to be approved Earth Observing System (Eos) is being discussed for possible deployment on the polar platforms to be furnished as part of the Space Station program by both NASA and ESA.

In Planetary Exploration, the major emphasis for near-term Space Station activities is the potential development, if approved, of two important attached payloads to support planetary research: the Astrometric Telescope Facility (ATF) and the Cosmic Dust Collector Facility (CDCF). ATF will address an important and long-desired goal: the search for other planets around nearby stars. By making precise, long-term measurements of the motions of stars, ATF can detect the presence of planets as small as Uranus or Neptune around them. The CDCF will collect tiny particles of interplanetary and perhaps interstellar dust. Returned to Earth, and analyzed in detail, these particles can provide unique and fundamental information about chemical processes in the early solar system and perhaps in interstellar space.

The Space Station will be a critical base for research in the Earth sciences, life sciences and microgravity sciences as earlier described. In short, we are depending on Space Station to be the core for an aggressive and far ranging space science and applications program in the 1990's and beyond. We are working closely with all parties involved to ensure that the science return from the Space Station is commensurate with our National investment.

## SUPPORTING PROGRAMS

Supporting programs in Suborbital Research and in ground-based Research and Analysis are an essential complement for all Space Science and Applications flight mission activities. Our research and analysis activities were briefly discussed earlier. The

importance of the suborbital program is underscored by the hiatus in Shuttle flights. Suborbital flights of balloons, aircraft, and sounding rockets provide observations that complement the results of more complex orbital missions and also facilitate the development and testing of instruments that will eventually make orbital observations.

The Research and Analysis program provides even more diverse and essential science support functions: theoretical studies, laboratory research, advanced technology and mission definition, ground-based observations to support flight missions, and extended analyses of data from completed missions. These supporting programs are a significant fraction of the basic research support to the university, government, and industrial scientific researchers, who are the core of the Space Science and Applications Program.

Continuing problems with our heavy-lift balloons led to the development and selection of a new, balloon-quality, polyethylene film (Raven Astrofilm-E) during 1986. Also in 1986, we successfully launched 26 balloons (out of 36 attempts) to support observations in upper atmosphere science, astrophysical research, and solar physics. A total of 49 flights are planned for 1987, including test flights to qualify balloons for heavier payloads (5,000 to 6,000 pounds), launches of heavy payloads from the semi-permanent launch site at Fort Sumner, New Mexico, transglobal flights starting from Alice Springs, Australia, and a major expedition to Canada.

The sounding rocket program achieved 31 successes (out of 33 attempts) in 1986 to support studies in astronomy, solar and planetary physics, plasma physics, and upper atmospheric physics. The program will be expanded to about 40 launches per year in 1987 and 1988 to ease the impact on scientists whose experiments are grounded until the Space Shuttle resumes flight operations. A major activity early in 1987 will be a series of sounding rocket launches, including eight NASA payloads, from a mobile launch facility that will be sent to Greenland for studies of winter polar cap turbulence, electric fields over the aurora, and disturbed thermospheric winds.

The Kuiper Airborne Observatory (KAO), a C-141 aircraft equipped with a 91-centimeter telescope, is able to make astronomical observations above 91 percent of the Earth's atmosphere. The KAO is scheduled to make 72 research flights in FY 1987, permitting 29 groups of scientists to make measurements in the near-infrared and sub-millimeter wavelength spectral regions.

In our Research and Analysis program noted earlier in the discipline narratives, a major achievement during 1986 was the result of long-term studies of the positions and velocities of galaxies by Dr. Margaret Geller of Harvard University. Her findings are giving us a new picture of the universe, one in which galaxies seem to form along the surfaces described as

immense "bubbles" in intergalactic space rather than being evenly distributed.

## POTENTIAL FUTURE MISSIONS

The Space Science and Applications program continues to support advanced studies of possible future missions in order to define, select, and plan missions that are both scientifically exciting and cost-effective. Our efforts in Advanced Technology Development (ATD) for potential future missions have resulted in significant returns for other missions. To demonstrate this point OSSA commissioned a Technology Development Study to review the technological developments from two of our most important approved missions--the Hubble Space Telescope (HST) and Galileo. The study was conducted to give greater recognition to the outstanding technology that results from our space science missions. These ATD activities are clearly contributing to U.S. technological leadership, and should be recognized as such. Our advanced studies for potential future missions have a significant return, not only for space science and applications, but also for many other scientific endeavors. The survey focused on hardware and software technology developed over each project's life-cycle covering the period from pre-project approval through integration and test.

Data collected from interviews, questionnaires, and technical publications resulted in over 100 Galileo and HST technology developments being identified and documented. Of those identified, 42 were categorized as outstanding or significant, according to criteria established in the study. The survey also identified more than 100 resulting publications, helping NASA to disseminate this valuable information on NASA-developed technology.

Contributions to future scientific missions include an expanded and computerized guide star catalogue, significant advancement in fabrication of large systems, high resolution optics, and improved detectors. Other contributions to future NASA missions include advancements in radiation hardened electronics, software development and extensive advancements in contamination control procedures. Several of the technology items developed for NASA's Galileo and HST missions have also contributed to commercial applications. Examples from Galileo include a miniaturized turbine pump and charge coupled devices now being utilized in solid-state automatic cameras. The study clearly demonstrates that our moderate investment in the development of advanced technology not only assures our technical readiness to implement missions, when approved, with lower risk, but also provides new technology with potential applications in other areas.

I would like to describe briefly some of the more exciting candidate missions for the future.

Astrophysics

The main thrust of our future missions in space astronomy is to make available four Great Observatories to study the universe across the entire electromagnetic spectrum. Two potential new programs will complete this effort: the Advanced X-ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF). Another future mission under consideration is planned to test Einstein's General Theory of Relativity.

The third of the four Great Observatories, AXAF will use a nested array of six pairs of mirrors with a 10-meter focal length to improve observational resolution and sensitivity in the X-ray region by a factor of 100 or more. These observations are of interest to a broad range of the scientific community because they promise new information on the birth and death of stars, and the nature of quasars, pulsars, neutron stars and black holes. Two contractors, Lockheed and TRW, have completed parallel definition studies with the goal of being ready for flight in the mid-1990s.

The last of the four Great Observatories will be SIRTF, an observatory for infrared astronomy that will use long mission life, precision cryogenic optics, and dramatic increases in the state of the art in detectors to give astronomers 1,000 times greater sensitivity than its predecessor, IRAS. In 1987 studies of detector technology, instruments concepts, and mission options continue. We hope to launch SIRTF in the late 1990s to complete the Great Observatories program.

Planetary Exploration

Studies of future planetary missions are being carried out in more detail to expand the exploration concept recommended by the Solar System Exploration Committee (SSEC): a "Core Program" of exciting, cost-effective Planetary Observer and Mariner Mark II missions (to the inner and outer regions, respectively, of the solar system), to which are added major Augmentation Missions involving both high science yield and significant technical challenge.

Currently, the primary focus of this activity is the Comet Rendezvous/Asteroid Flyby (CRAF) mission proposed to be the first project for the new Mariner Mark II spacecraft. This mission, after a close encounter with an asteroid, will rendezvous with a comet and fly in tandem with it in order to study directly the comet nucleus and observe the dynamic behavior of a comet (both its nucleus and coma) over a period of several years. Late in 1986, the mission science payload was selected for the CRAF mission (now named Mariner Tempel 2). This group of exciting investigations includes a penetrator that will be shot from the spacecraft into the nucleus of the comet to obtain the first direct information about the nature, organic and inorganic

materials, and the ices that comprise the comet's nucleus.

During 1988, studies of the Mariner Tempel 2 mission will be carried forward in more detail. In addition, several other missions in the "Core Program" will be studied. These include Lunar Geoscience Observer, a mission to globally map the Moon and to study its potential resources, Near-Earth Asteroid Rendezvous Observer, a mission to undertake the first long-term encounter with an asteroid, and a Saturn Orbiter/Titan Probe mission that would make a long-term study of Saturn and probe the atmosphere and surface of its giant moon Titan. This latter mission, called Cassini, is now being studied as a possible NASA-ESA cooperative project.

In addition, studies of two possible Augmentation Missions will be expanded: a Mars Surface Sample Return and a Comet Nucleus Sample Return. Both of these missions would produce a major increase in our understanding of these bodies by returning samples to Earth for analysis in terrestrial laboratories.

CONCLUSION

The FY 1988 budget request will provide for continued progress in the space science and applications disciplines. It will support our efforts to maintain the momentum of our past achievements, and it will ensure the readiness of approved missions for the resumption of Space Shuttle flights. It will also ensure that we are ready to make full use of the unique capabilities of the Space Station. This budget request will also support, through the "Vitality Program", our efforts to preserve and maintain the science research base that is critical to maintaining U.S. leadership in space.

Thank you.

# OFFICE OF SPACE SCIENCE AND APPLICATIONS
# FY 1988 BUDGET REQUEST
## (DOLLARS IN MILLIONS)

| | FY 1986 BUDGET | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|---|
| PHYSICS AND ASTRONOMY – TOTAL | 569.3 | 552.8 | 567.1 |
| HUBBLE SPACE TELESCOPE DEVELOPMENT | 125.8 | 101.3 | 98.4 |
| GAMMA RAY OBSERVATORY DEVELOPMENT | 85.3 | 50.5 | 49.1 |
| SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT | 79.4 | 74.6 | 75.4 |
| SPACE STATION PAYLOAD AND PLANNING | – | 15.5 | 20.0 |
| EXPLORER DEVELOPMENT | 48.2 | 56.7 | 60.3 |
| MISSION OPERATIONS AND DATA ANALYSIS | 111.7 | 125.7 | 128.1 |
| RESEARCH AND ANALYSIS | 49.0 | 53.4 | 60.1 |
| SUBORBITAL PROGRAMS | 69.9 | 75.1 | 75.7 |
| PLANETARY EXPLORATION – TOTAL | 353.6 | 358.4 | 307.3 |
| GALILEO DEVELOPMENT | 64.2 | 71.2 | 55.3 |
| ULYSSES | 8.8 | 10.3 | 10.8 |
| MAGELLAN | 120.3 | 92.6 | 59.6 |
| MARS OBSERVER | 33.8 | 35.8 | 29.3 |
| MISSION OPERATIONS AND DATA ANALYSIS | 67.0 | 80.0 | 77.0 |
| RESEARCH AND ANALYSIS | 59.5 | 68.5 | 75.3 |
| LIFE SCIENCES – TOTAL | 66.1 | 72.2 | 74.6 |
| FLIGHT EXPERIMENTS | 32.1 | 30.4 | 32.9 |
| RESEARCH AND ANALYSIS | 34.0 | 41.8 | 41.7 |
| SPACE APPLICATIONS | 487.5 | 569.3 | 569.3 |
| SOLID EARTH OBSERVATIONS | | | |
| SHUTTLE PAYLOADS | 21.8 | 21.8 | 21.1 |
| GEODYNAMICS | 30.0 | 32.1 | 33.1 |
| RESEARCH AND ANALYSIS | 19.1 | 21.9 | 22.6 |
| SUBTOTAL | 70.9 | 75.8 | 76.8 |

Chart 1

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# OFFICE OF SPACE SCIENCE AND APPLICATIONS
# FY 1988 BUDGET REQUEST
## (DOLLARS IN MILLIONS)

| | FY 1986 BUDGET | FY 1987 BUDGET | FY 1988 REQUEST |
|---|---|---|---|
| ENVIRONMENTAL OBSERVATIONS | | | |
| INTERDISCIPLINARY RESEARCH AND ANALYSIS | 1.0 | 1.1 | 1.1 |
| UPPER ATMOSPHERE RESEARCH AND ANALYSIS | 31.1 | 33.4 | 34.4 |
| OCEANIC PROCESSES RESEARCH AND ANALYSIS | 17.4 | 20.8 | 21.5 |
| ATMOSPHERIC DYNAMICS/RADIATION RESEARCH AND ANALYSIS | 28.7 | 31.9 | 32.9 |
| SPACE PHYSICS RESEARCH AND ANALYSIS | 16.8 | 21.0 | 21.5 |
| SHUTTLE PAYLOADS | 5.3 | 12.0 | 19.4 |
| TETHER PAYLOADS | 6.4 | 1.0 | 3.1 |
| EARTH RADIATION BUDGET EXPERIMENT | 1.9 | – | – |
| MISSION OPERATIONS AND DATA ANALYSIS | 35.0 | 33.6 | 26.8 |
| UPPER ATMOSPHERE RESEARCH SATELLITE MISSION | 114.0 | 114.2 | 95.4 |
| SCATTEROMETER | 14.0 | 32.9 | 22.7 |
| OCEAN TOPOGRAPHY EXPERIMENT | – | 19.0 | 90.0 |
| GLOBAL GEOSPACE SCIENCE | – | – | 25.0 |
| SUBTOTAL | 271.6 | 320.9 | 393.8 |
| MATERIALS PROCESSING IN SPACE | | | |
| RESEARCH AND ANALYSIS | 12.1 | 13.9 | 14.4 |
| MATERIALS EXPERIMENT OPERATIONS | 18.9 | 34.0 | 31.5 |
| SUBTOTAL | 31.0 | 47.9 | 45.9 |
| COMMUNICATIONS | | | |
| RESEARCH AND ANALYSIS | 9.8 | 13.0 | 14.4 |
| SEARCH AND RESCUE | 1.1 | 1.0 | 1.3 |
| TECHNICAL CONSULTATION AND SUPPORT | 2.5 | 3.2 | 3.4 |
| EXPERIMENT COORDINATION AND OPER. SUPPORT | 1.1 | 1.3 | 1.4 |
| ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE | 81.9 | 85.0 | – |
| SUBTOTAL | 96.4 | 103.5 | 20.5 |
| INFORMATION SYSTEMS | 17.6 | 21.3 | 22.3 |
| TOTAL OFFICE OF SPACE SCIENCE AND APPLICATIONS | 1476.5 | 1552.6 | 1508.3 |

Chart 2

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Questions submitted by Chairman Nelson during the March 3, 1987, hearing at which Dr. Edelson testified on NASA's FY 1988 budget.

**Overall Budget Request**

QUESTION E-1:

What is the five (5) year runout of the OSSA budget based on the FY 1988 request?

ANSWER E-1:

(Dollars in Millions - Rounded)

| FY 1988 | FY 1989 | FY 1990 | FY 1991 | FY 1992 |
|---|---|---|---|---|
| 1,500 | 1,700 | 1,700 | 1,600 | 1,500 |
| 1,508 | 1,723 | 1,720 | 1,641 | 1,543 |

QUESTION E-2:

What is the five (5) year runout of the OSSA budget if the ACTS program is restored, the Mars Observer is launched in 1990, and the High Resolution Solar Observatory is initiated?

ANSWER E-2:

(Dollars in Millions - Rounded)

| FY 1988 | FY 1989 | FY 1990 | FY 1991 | FY 1992 |
|---|---|---|---|---|
| 1,700 | 1,800 | 1,800 | 1,700 | 1,500 |

In addition to the five (5) year impact above, the Mars Observer would require $20 million additional funds during FY 1987 for a 1990 launch.

**Impact of Challenger Accident**

QUESTION E-3:

What is the total cost impact to science as a result of the Challenger accident?

ANSWER E-3:

The direct cost impact to the science budget as a result of the Challenger accident is estimated to be about $1.2 billion, related to the slippages of our major flight projects. The impact on Shuttle-attached payloads is very difficult to measure since many specific missions are delayed beyond the time period covered by the manifest.

QUESTION E-4:

What is the total cost impact to science as a result of the Centaur cancellation?

ANSWER E-4:

The cost impact to the science budget as a result of the Centaur cancellation is estimated to be $50-75 million.

QUESTION E-5:

What will be the impact on the Space Science budget and programs if the first Shuttle flight is delayed beyond February 1988?

ANSWER E-5:

An overall budget impact analysis of further Shuttle delays has not yet been made, but is expected to be addressed as part of our internal budget process leading up to the formulation of our FY 1989 budget. Each OSSA project that is sensitive to the Shuttle manifest has developed a strategy to accommodate changes in the manifest. Specific impacts of a slippage would depend in part on how soon the slippage is recognized and how soon launch and operational staffs are phased in.

In general, however, significant costs will be incurred for any major shuttle delay particularly in regards to our launch-ready and nearly completed spacecraft.

**Advanced Communications Technology Satellite (ACTS)**

QUESTION E-6:

What are the budgetary requirements each year for keeping ACTS on track for a 1990 launch?

ANSWER E-6:

Requirements by fiscal year are:

| | |
|---|---|
| 1988 | $84 Million |
| 1989 | $76 Million |
| 1990 | $38 Million |

QUESTION E-7:

When will NASA announce a firm 1990 manifest date for ACTS?

ANSWER E-7:

OSSA has requested a 4th quarter 1990 STS launch for ACTS. We expect that this will be reflected in the next STS Manifest.

QUESTION E-8:

When will the TOS upper stage be ready for integration onto the ACTS spacecraft?

ANSWER E-8:

The TOS will be available for integration with ACTS during the 3rd quarter of CY 1990.

## High Resolution Solar Optical Telescope (HRSO)

QUESTION E-9:

What would be the total cost of HRSO and how much would be needed in FY 1988?

ANSWER E-9:

The total cost of HRSO as a Spacelab payload is currently projected as $180 - $190 million. The changes which need to be made to HRSO and the associated cost deltas to make it a Space Station payload are being studied now with results due by mid-summer. Funding of $12 million is required in FY 1988 to begin the development phase.

QUESTION E-10:

What are the likely candidates for basing HRSO (i.e., Shuttle or Space Station) and what are the advantages and disadvantages?

ANSWER E-10:

The original plan for HRSO when it was the Solar Optical Telescope was to fly it several times as a Shuttle/Spacelab payload and then to attach it to the manned Space Station as the major element of the Advanced Solar Observatory (ASO). It is still desirable to follow a similar plan for HRSO, that is, to fly it once as a Shuttle/Spacelab to check its performance and operations before committing it to long-term operations on the Space Station. This approach has several advantages: first HRSO would allow continuous viewing of the Sun for 7 to 10 days and thus address a class of scientific objectives which could not be performed in the low inclination orbit of the Space Station. Once on the Space Station, HRSO would be able to perform long-term observations of the Sun only during the daylight portion of the orbit. Second, HRSO could be designed and built to currently known interfaces (Shuttle/Spacelab), and adapted to Space Station interfaces once they are firmly established.

QUESTION E-11:

How do the science and technical objectives of HRSO and SOT compare?

ANSWER E-11:

The prime science objectives of HRSO are identical to those of SOT, with some compromise of the spatial resolution (0.1 to 0.13 arc second) in order to achieve substantial reduction in total cost. The major scientific difference between SOT and HRSO is the removal of the ultraviolet (UV) capability as an integral part of the instrument. In order to preserve the option for future UV science objectives, HRSO has the capability to add a strap-on UV telescope to it. A possible candidate instrument would be the High Resolution Telescope and Spectrograph which flew on the Spacelab 2 mission. Discussions are being held with the British for them to provide or collaborate on the development of a UV instrument. Additionally, formal discussions are in progress with Germany to provide a major

portion of the visible spectrograph. This will not only reduce the overall cost but will enhance the scientific return. Technically, there are several major differences between SOT and HRSO. Not only is HRSO smaller, 1.0 meter vs 1.3 meter primary mirror, it also does not have the multiple internal stages of active optics that SOT had. HRSO relies more heavily on an external pointer like the Instrument Pointing System to provide the arc second pointing and on one internal stage of active optics to provide the sub-arc second pointing that is required. Additionally, HRSO has the capability of only one focal plane instrument package and one strap-on instrument whereas, SOT's capability was two and two, respectively.

**Advanced X-Ray Astrophysics Facility (AXAF)**

QUESTION E-12:

What would have been gained by entering a phase C on AXAF in FY 1988?

ANSWER E-12:

The Advanced X-ray Astrophysics Facility (AXAF) completed 32 months of Phase B (definition) studies in January 1987. In June 1986, NASA conducted an independent technical and cost review of AXAF. The program was found to be sufficiently defined to proceed to the next stage, i.e., design and development. A start of Phase C on AXAF in FY 1988 would have allowed the program to advance to the next logical step, i.e., a complete design of the observatory. However, a Phase C start for AXAF in FY 1988 would have been more costly than the Pathfinder Program which NASA proposed. The Pathfinder Program was designed to allow NASA to concentrate its limited resources on the optical and instrument technologies for AXAF, which were found to be the more critical.

QUESTION E-13:

Why was the "pathfinder" program, to work on the long lead optics technologies for AXAF, not included in the FY 1988 budget?

ANSWER E-13:

The Pathfinder Program was not included in the FY 1988 budget due to severe budgetary constraints.

QUESTION E-14:

Can you complete the contractor down select in FY 1988 within the budget request?

ANSWER E-14:

Yes, the budget request for FY 1988 includes sufficient funding in the Research and Analysis (R&A) line item to allow for the selection between the two competing contractors in FY 1988.

QUESTION E-15:

When will you decide whether AXAF will be part of the Space Station platform concept?

ANSWER E-15:

It is NASA's plan to have the selected contractor for AXAF work with the selected contractors for the Space Station platforms to assess the feasibility of using selected platform modules on AXAF. We plan to complete this assessment by September 1988, and to make a decision on the platform concept at that time.

QUESTION 16:

Would AXAF use resource modules derived from Space Station, GRO, or Space Telescope?

ANSWER E-16:

The AXAF module heritage to either the Hubble Space Telescope or the Gamma Ray Observatory will be decided when the selection of the prime contractor is made. Following the prime contractor selection, an assessment of the use of Space Station platform modules will be made as discussed in Answer 15.

Comet Rendezvous Asteroid Flyby (CRAF)

QUESTION E-17:

When will CRAF get a new start?

ANSWER E-17:

Comet Rendezvous Asteroid Flyby (CRAF) is a principal FY 1989 New Start candidate within the Office of Space Science Applications (OSSA). OSSA sponsored a nonadvocacy Technical Definition and Cost Review of the CRAF mission on June 9-10, 1987. The OSSA recommendation on an FY 1989 New Start for CRAF was presented to the Administrator on July 24, 1987. Given a positive response from the Administrator, OMB and Congress to the New Start Proposal, an FY 1989 start will allow the CRAF mission to be launched in February 1993.

QUESTION E-18:

How does the delay in CRAF affect other programs like Cassini?

ANSWER E-18:

Cassini is being planned as the OSSA New Start candidate for FY 1991, two years after the CRAF New Start. It will be the second Mariner Mark II spacecraft and could be launched in FY 1995. A number of technology developments must proceed on schedule in order for the CRAF mission to launch in February 1993. Cassini will, of course, require these same technology developments. The CRAF mission will also provide the opportunity to demonstrate and space-qualify several Mariner Mark II technical capabilities required for

Cassini, but not for CRAF, one example being the high frequency communications capability (K-band, at 32 Ghz) required to return from the Saturn distance the massive amounts of data acquired by Cassini.

QUESTION E-19:

What is the funding for Mariner Mark II technology development in FY 1988, 1989, and 1990?

ANSWER E-19:

The funding for Mariner Mark II technology development is as follows: For FY 1988, $15.3 million; assuming the New Start for CRAF in FY 1989, the funding for FY 1989 is $46.0 million; and $206.0 million for FY 1990.

Space Telescope

QUESTION E-20:

How would the Space Telescope mission be impacted if the Shuttle mission were flown at only 100 percent engine thrust?

ANSWER E-20:

Since the design changes in the Shuttle are still in development, new performance figures have not yet been firmly established. However, based upon previous performance figures, it does not appear that operation at 100 percent engine thrust will impact the Hubble Space Telescope deployment mission. The main engines would burn somewhat longer to achieve the desired altitudes using the direct insertion trajectory planned for this mission.

QUESTION E-21:

What is the status of the solar cells and power baseline for the telescope? What will happen if the solar cells do not deliver the full power required?

ANSWER E-21:

The development of the flight solar arrays has been completed and the flight arrays delivered. These arrays met design specifications and are available to support the currently-planned launch of the telescope in late 1988.

Our solar array development plan has always included second-generation, higher performance solar cell arrays, to be available as orbital replacement units during a maintenance mission. Since the launch of Space Telescope has been delayed, the higher-performance solar arrays may be available for the initial deployment.

Current estimates of available power show a positive margin at launch over the projected flight power demand, based on actual load data obtained last summer in thermal-vacuum simulations of space conditions. The thermal-vacuum tests showed that power demands due to heater loads were somewhat higher than expected. We are making

changes to some hardware and some operating procedures to increase the initial power margin and to ensure satisfactory power margin over the HST lifetime. Additionally, under the M&R program, replacement Nickel-Hydrogen batteries are planned to be developed which will serve as on-orbit replacements or incorporated on the initial flight depending on launch schedule and test results.

If the power output of the solar arrays on orbit decays below that required for satisfactory operation, we plan to replace them during a maintenance mission.

QUESTION E-22:

What is the present status of the modal test for Space Telescope?

ANSWER E-22:

Last Spring a modal test defined the characteristic vibrational modes of the HST spacecraft. This test established the dynamic behavior of the spacecraft in the "free-free" mode, while it was isolated from the dynamic influence of other structures.

In December we conducted another modal test to define the interactions between the Space Telescope and the structures that will support it in the Shuttle cargo bay. This test used the impedance technique to characterize the dynamic response of the Space Telescope spacecraft to loads applied through its trunnions.

As a result of these tests, the dynamics of the spacecraft are well understood. Test results are consistent with design predictions. The Space Telescope Project Office is now reviewing the test results with the Shuttle Project Office to ensure a common understanding and agreement on the dynamics of the Shuttle-Space Telescope system.

## Space Station

QUESTION E-23:

Can you explain the "line item" status NASA has announced for Space Station instruments?

ANSWER E-23:

The Office of Space Science and Applications has established a line item within its budget for Space Station Integration. This program will provide focused, coordinated support for our scientific Space Station utilization and accommodation studies, the definition and development of common use elements for Space Station, such as common laboratory equipment, instrument carriers, and information system architecture and multi-discipline elements. In addition, this program will provide seed funds to stimulate identification of experimental opportunities enabled by Space Station (e.g., "Quick is Beautiful" and large instrument structures).

Actual science missions using Space Station will, as in the past, be defined as a function of the thrusts and priorities of the discipline science programs, and will be slated for deployment on

the Space Station when that provides the best scientific accommodation.

QUESTION E-24:

When will NASA issue an announcement of opportunity for Space Station research?

ANSWER E-24:

The first announcements for participation in Telescience Testbed research, leading to operational and information system techniques for use on Space Station, will be issued later this year. Announcements for experiment opportunity definition studies will be issued in FY 1988. Announcements for the first flight opportunities, scheduled to begin in 1993, should be issued in 1989.

QUESTION E-25:

When will the Earth Observing System (EOS) on the Polar Platform get a new start? Is EOS competing with other new starts like AXAF and CRAF?

ANSWER E-25:

It is impossible to accurately predict the year in which any future mission will receive its new start as this process is an element in the preparation of the President's budget proposal and is subject to Congressional action. The Earth Orbiting System (EOS) is preparing to be a candidate for a new start in a timely fashion compatible with the Space Station Platforms programs. The degree to which EOS is in competition with AXAF or CRAF or any other potential new starts depends on the overall level of the NASA budget and the choices this dictates among the many opportunities for accomplishment in the space activities of our nation.

QUESTION E-26:

What will you do if the West Coast Shuttle operations are cancelled?

ANSWER E-26:

In case there is no shuttle launch capability from the Western Test Range (WTR), each polar platform together with its payload will use an ELV launch to its operational (800-900 km) near polar (98deg) orbit.

At present, we are planning two possible approaches:

a) Continue to use satellites rather than large integrated platforms. In this case, no servicing or repair would be planned.

b) Use the planned Space Station derived platform concept. In this case, an ELV in an automatic docking mode and a platform based telerobot will perform the necessary servicing activity. Instruments or modules, etc., to be replaced would be discarded in orbit.

QUESTION E-27:

When will you have a Space Station Integration Office to collect and focus all your Space Station science requirements?

ANSWER E-27:

Our Space Station Integration office is currently defined and functioning in an ad hoc arrangement. Funding for this function is provided under the budget line item discussed in Question 23. Formal establishment as an organizational element is under review.

QUESTION E-28:

When will you begin the Science Application Information System (SAIS) to provide for the science data management associated with the Space Station?

ANSWER E-28:

Definition studies for the Science and Applications Information System (SAIS) began last year. This year, we are pursuing development of the system architecture, and its interfaces with the systems provided by Space Station and the Office of Tracking and Data Systems. Also, this year we have initiated a Telescience Testbed program to involve the university-based user community in rapid-prototyping to evaluate system design concepts and technologies to enable telescience. Continuation of this program will lead to design and development of system elements in FY 1989. Our philosophy has been that while SAIS architecture definition, design, test-beds, and development of prototypes and multi-discipline use end items would be centralized, the development of discipline and mission specific end items would be handled in the discipline programs, where appropriate tradeoffs for expenditure of research dollars can be made.

QUESTION E-29:

How will you prioritize the needs of life science and materials science so that we can begin planning rack allocations on the Station?

ANSWER E-29:

We have underway a Pressurized Volume Utilization Study, which has been commissioned to examine the best (from a scientific point of view) use of the pressurized volume of the Space Station, without a priority regard for allocation of rack space. This study has already indicated an oversubscription of available rack space and an apparent redundancy between requirements submitted by the U.S. and the international partners. As this study concludes near the end of the year, we will arrive at a detailed understanding of the true requirements, compatibilities, and incompatibilities. Resolution of the remaining "scrubbed" incompatibilities will involve a complex process involving all concerned communities, including U.S. science, commercial, Space Station engineering and operations, and corresponding international communities. This will be the first "test" of the Station's resource allocation process.

## Space Applications

QUESTION E-30:

Why, in the new agency goals, has NASA deleted Space Applications?

ANSWER E-30:

The agency is in the process of developing the long-term program and institutional goals. In this process, all aspects of the program are being carefully reviewed, including the Agency's role in the Space Applications. Two of the NASA Management Study Group (Phillips Committee) recommendations specifically address this issue: how to organize the Office of Space Science and Applications with an eye toward effectiveness; and how NASA and OSSA should give high priority to applications programs to maintain relevance to practical needs. These recommendations will be seriously considered and will be reflected in the Agency Goals and Objectives.

QUESTION E-31:

What are you doing to identify the funding needed, the long range goals and the role of your office in materials processing in space (as opposed to NASA's commercial office)?

ANSWER E-31:

The Microgravity Science and Applications (MSA) Division is in the process of developing a long-range plan which will lay out the program activities for the next 10 to 15 years. The first step in the development of the plan is being accomplished through the MSA Discipline Working Groups (DWG). There are six DWGs, one in each MSA discipline area (electronic materials; fluid dynamics and transport phenomena; combustion; glasses and ceramics; metals and alloys; and, biotechnology). These groups, made up of representatives from industry, academia, and government agencies, are developing science and applications goals and priorities for their respective disciplines. When completed, the DWG reports will be woven into an overall science and applications strategy for the MSA program.

We will then take that strategy and identify the hardware and facility requirements to meet the identified goals, as well as a time-phased plan and necessary funding. The overall plan is scheduled for completion in late summer 1987.

The role of the Office of Space Science and Applications in materials processing in space includes the conduct of basic and applied research in the effect of the microgravity environment on materials, fluids, and processes. It is our responsibility to support research that is compatible with industry's interests (i.e., that will provide enough data for industry to make knowledgable judgements regarding investment in space processing). Obviously, transfer of research results through publication in open literature and other means is essential. Our role also includes research in fundamental physics and chemistry, and providing the essential theoretical base for the understanding of materials processing in the space environment.

QUESTION E-32:

What recommendations did the Phillips Committee make specific to the organizational placement and management of Space Applications?

ANSWER E-32:

As noted in answer #30, the Phillips Committee recommended that the Organization of OSSA should be reviewed, and that the Agency should give high priority to space applications. Responses to these recommendations are being formulated, and we expect to treat these issues in our NASA planning process and budget activities.

QUESTION E-33:

a. What role can be played by suborbital ELV payloads for microgravity research?

b. Is NASA planning on instituting such a program?

ANSWER E-33:

a. The use of ELV's for microgravity payloads would require a means of sample recovery, such as a recoverable capsule. While the concept is attractive, since it potentially would provide additional flight opportunities and a relatively stable low-gravity environment, current capsule configurations have extreme limitations on available power. Most microgravity experiments require a high power usage, as well as active cooling, which is not available with ELV's. There is some limited utility for experiments which are essentially passive, e.g., blood storage experiments.

b. NASA is exploring the possibility of using ELV's with recoverable capsules for life sciences experimentation. As for microgravity, we are looking at the potential for use in the long term, when higher power may be available.

Vitality Package

QUESTION E-34:

What percent of the vitality money actually goes toward university group funding as opposed to buying infrastructure like research aircraft and spacecraft engineering studies?

ANSWER E-34:

The purpose of the Vitality Package is to provide additional funds to the research community, particularly universities, to help researchers maintain active research programs during the present major hiatus of flight opportunities. As a result, the university funding in the Vitality Package is estimated to be 80-90 percent which is significantly higher than the normal OSSA percentage of 12-14 percent.

QUESTION E-35:

When will these dollars actually get to the university groups?

ANSWER E-35:

Over 80 percent of the FY 1987 tasks to be supported with the Vitality Package funds have been reviewed and approved. Although the funding has been allocated for final distribution, there is no practical way to determine when the funds will actually reach the universities. Naturally, funding added to existing contracts/grants can be implemented much quicker than new tasks that may require proposals, evaluations, and new contractural documents. In general, it can be safely assumed that most, if not all of the funds earmarked for universities will be in their hands by the end of the fiscal year.

QUESTION E-36:

How many new sounding rocket flights will be achieved?

ANSWER E-36:

It is expected that the number of sounding rocket flights will increase by five flights per year and that a capability will be established to fly two Aries flights per year rather than the current capability of one flight every two years.

QUESTION E-37:

How many new balloon flights will be achieved?

ANSWER E-37:

No new balloon flights are planned for FY 1987. For FY 1988 and beyond, the balloon flight requirements are under study.

**Small Science**

QUESTION E-38:

For the following astrophysics explorer class programs, please provide the date in which they were proposed, the estimated launch date and the development cost in FY 1988 dollars.

-IRAS -IUE -COBE -EUVE -XTE -FUSE/LYMAN

ANSWER E-38:

The current Explorer program has primarily evolved from two Announcements of Opportunities (AO's) released in July of 1974. One hundred and seventy-five proposals were received in response to these AO's. An extensive review and evaluation program was conducted to determine the most promising missions, and five missions were selected for funding. In the Astrophysics area, the Infrared Astronomical Satellite (IRAS) was selected for development, and the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE) were selected for more detailed study

before initiation of development efforts.

While the concept of an X-ray timing mission was proposed in 1974, the X-ray Timing Explorer (XTE) investigations were selected in 1982 under an AO issued in 1980. The Far Ultraviolet Spectroscopy Explorer (FUSE) was first included in the planning of the Astrophysics Program in 1981 as the highest-priority, moderate, new mission recommended in Astronomy and Astrophysics for the 1980's, the report of the Astronomy Survey Committee of the National Academy of Sciences. A similar mission proposed by the European Space Agency is known as LYMAN, and some preliminary, joint concepts have been explored. While a proposal for a conceptual design of FUSE has been submitted in response to the Dear Colleague Letter of the Explorer Concept Study Program, it has not been reviewed or selected.

The status of the requested Explorers follows: IRAS was launched on January 25, 1983. The cost to build IRAS, including approximately $80 million of foreign participation, was $162 million in real year dollars, or $214 million in FY 1988 dollars. Funding began in FY 1977. Scientists are continuing to analyze the data from this scientifically fruitful mission.

The International Ultraviolet Explorer (IUE) was launched on January 29, 1978, and is still operating. IUE was initially proposed in 1970 and funding began in FY 1974. The IUE mission cost, including foreign participation of about $16 million, was $29 million in real year dollars, or total of about $107 million in FY 1988 dollars.

COBE, which requires a polar orbit, will be launched in 1989 on an expendable Delta launch vehicle instead of the Shuttle, as previously planned. The change in launch vehicle was necessary due to the postponement of the West Coast STS launch capability. COBE development was initiated in FY 1982. All instruments are currently in hand, and spacecraft modifications necessary for the Delta launch are underway. The estimated run out cost for this mission is $145 million to $155 million in real-year dollars, or $165 million to $175 million in FY 1988 dollars.

EUVE launch readiness is planned for FY 1991. The EUVE payload entered the development phase in FY 1986 when the spacecraft bus, designated the Explorer Platform, was selected. The cost of the payload development effort is estimated in real-year dollars at $80 million to $90 million, or $75 million to $85 million in FY 1988 dollars. The cost of the Explorer Platform, which will be capable of supporting several Explorer payloads during its in-orbit lifetime, is estimated at $100 million to $115 million in real-year dollars, or $115 million to $130 million in FY 1988 dollars.

The Shuttle will rendezvous with the Explorer Platform and retrieve the EUVE payload and replace it with the XTE payload, now under definition. The XTE launch is planned for 1994. Development of XTE is planned to begin in FY 1990 as part of the ongoing Explorer budget line, and is estimated to cost between $50-80 million in FY 1988 dollars.

The FUSE/LYMAN mission has not yet been selected for study, and therefore, no cost estimate or planned launch date is available. While some preliminary concepts have been explored, there is still no conceptual design on which to base a cost estimate.

QUESTION E-39:

Please explain the statement in the submitted budget that XTE is "the last currently planned major effort in the Explorer line."

ANSWER E-39:

The X-ray Timing Explorer (XTE) is the last Explorer after Cosmic Background Explorer (COBE) and Extreme Ultraviolet Explorer (EUVE) for which investigations have been selected for definition through Announcement of Opportunity issued in 1974 and 1980. XTE is planned to start development in FY 1990, when Explorer Program funding permits. A Dear Colleague Letter was issued in 1986 apprising the scientific communities of opportunities to begin study of concepts for new Explorer missions which, if selected after definition study, could begin development following the start of development of XTE.

QUESTION E-40:

When will the 43 proposals received as a result of the 1986 Dear Colleague Letter be evaluated?

ANSWER E-40:

Evaluation of these proposals is tied to the ability of the Explorer Program to begin the development of new missions. If the program is unable to start new missions in a timely way, because of funding, the evaluation and selection of new missions will be postponed. However, planning for evaluation of the proposals is proceeding so that we are prepared to make a selection of new mission concepts should an increase in funding for the Explorer Program become available in Fiscal Year 1989. If this increase does not occur, then selection of new missions will be deferred.

QUESTION E-41:

What additional funding and management changes would be required such that a flight rate of one mission per year is achieved?

ANSWER E-41:

Funding of approximately $130 million (FY 1986) per year has been recommended by the Space Science Board to fulfill the recommendations of one launch per year by their Committee on Space Astronomy and Astrophysics and their Committee on Solar and Space Physics. We do not anticipate any fundamental changes in the programs management structure.

QUESTION E-42:

What was the cost impact of the Challenger Accident on the Explorer program?

ANSWER E-42:

It is estimated that approximately $110 million of additional costs over several fiscal years have impacted to the Explorer Program as a result of the Challenger accident. This estimate includes costs resulting from such items as redesign of COBE to be compatible with a Delta launch vehicle (necessary because of postponement of Shuttle capability at Vandenberg Air Force Base), lack of retrieval of the Solar Maximum Mission spacecraft for use by EUVE and XTE, delayed launch schedule for Roentgen Satellite, disturbance of EUVE development schedule, and payload interface change activities.

QUESTION E-43:

Please identify which specific Shuttle flights from 1988 through 1995 can reasonably accommodate a Spartan payload.

ANSWER E-43:

The Agency baseline manifest dated October 1986 shows compatible cargos through April 1991 or STS-55. The out year portion beyond 1991, recognizes three launch slots of the baseline for ten Spartan flights. However if currently scheduled payloads are off-loaded to ELV's and the flight rate specified within the October 1986 baseline manifest is maintained, other opportunities for OSSA (Shuttle unique) payloads may become available. Spartan class payloads would be strong candidates, but will have to compete with other requirements.

As an example, each Global Positioning Satellite (GPS) moved to the Air Force's new MLV will free up 16,200 pounds of capability which would more than accommodate a Spartan, or a comparable payload, at 4500 to 5000 pounds.

QUESTION E-44:

Will the Spartan program continue to actively solicit and fund payloads?

ANSWER E-44:

The Spartan program is currently under review in light of the significant reductions in flight opportunities on the Space Shuttle. Any activity involving soliciting and funding of new payloads would strictly involve the resolution of the manifesting problems associated with Shuttle.

QUESTION E-45:

What plans does NASA have for initiating a small Scout class payloads program?

ANSWER E-45:

The mixed fleet study undertaken by NASA following the Challenger accident has considered the potential of a variety of ELV's for helping mitigate the shortage of space flight opportunities. The Scout vehicle, which has played an important role in many missions

over the past 15-20 years, could be used effectively to launch payloads with weights (spacecraft plus instruments) up to about 500 pounds. A one-day workshop held at the Goddard Space Flight Center on February 24, 1987, was organized for the specific purpose of evaluating the scientific benefits of small payloads that could be launched either by the Shuttle from a G.A.S. cannister or by a Scout. The workshop deliberations indicated that numerous payloads in the Scout weight class seem to be scientifically interesting. No firm plans yet exist to implement a small payloads program based on Shuttle or Scout launches, but it seems likely that budget augmentations will be sought to establish such a program, provided the tentative conclusions from the workshop are verified by further, detailed evaluations of their scientific merit.

QUESTION E-46:

What is the status of the SOFIA program the acquisition of an aircraft for that purpose?

ANSWER E-46:

The SOFIA program requires a 747 aircraft and a 3-meter telescope to be operated open port at altitude. NASA is presently studying both aircraft requirements and the modifications required to the aircraft to incorporate the telescope, and has allocated $0.5 million in FY 1987 for this purpose. The German government has expressed an interest in collaborating with NASA on the SOFIA program and is presently studying the development program for the 3-meter telescope to be incorporated into the aircraft.

We plan to present the SOFIA program as a candidate for development in FY 1989, identifying the entire development cost, including the aircraft and telescope. With German participation, the cost of the telescope itself would not accrue to NASA.

Mr. NELSON. Thank you, Dr. Edelson.

Before we get into the questions, how about, for the sake of some of our new members, give us a sketch of the great observatories and what you would like. Preparatory to your remarks, let me just say to the members, the Hubble Space Telescope is going to open up all kinds of new understanding to us because we are going to be able to see with this very powerful telescope what is going to be outside of the Earth's atmosphere, and therefore we can see so much more clearly in the visual spectrum what is out there in the universe.

But Dr. Edelson and his team of scientists conceive of having a number of other kind of observatories, which they call the Great Observatory Program. Why don't you sketch that for us very briefly?

Dr. EDELSON. Throughout the history of mankind, Mr. Chairman, humans have looked up to the skies and wondered about the celestial objects which they could see through a very narrow portion of the electromagnetic spectrum known as visible light. A great step forward was made in the year 1610 when Galileo looked up through his first telescope and saw the four moons of Jupiter and other celestial bodies.

Still, Galileo was looking through that what we now recognize as an extremely small window available to humans because of our vision, but we did not know that there were other electromagnetic emanations. Only after World War Two and through some rocket and balloon research did we get a glimpse of the fact that there were a broad range of emanations.

Through the sixties and seventies and in the eighties—let me mention here the IRAS infrared spacecraft—we learned that heavenly bodies of all kinds, stars, galaxies, clusters and very exotic objects, were emitting in every part of the electromagnetic spectrum, from infrared through the optical spectrum, the ultraviolet, x-rays, and into the very short gamma rays.

We are now at a capability where we have been able to take snapshots with small instruments and get some glimpse of the vast array of information that is there that will allow us to gain an understanding of the evolution of the universe, including our own solar system, which is a latter-day event, 4.5 billion years out of the history of the universe from the big bang of something like 15 billion years.

So we have planned the Great Observatory Program, four superspacecraft that will look in the optical, gamma ray, x-ray and infrared regions respectively, in chronological order of launch, with the Hubble Space Telescope, the Gamma Ray Observatory, both approved programs, the AXAF x-ray telescope, and the SIRTF, infrared telescope, which we are promoting for future new starts.

It is one of the most exciting, interesting and productive areas of science. The whole world is watching us. We are the undisputed world leader in past experience. We have a capability to do the engineering on the spacecraft in the software and controls, and we have the ability to develop the detectors and optics for the scientific instruments that no other country or capability in the world can even touch at the present time, and we are lined up now to do the Great Observatory Program.

We have a super brochure and so on to make available that tells this exciting tale. We will enter a new era with the Hubble Space Telescope when we launch that, hopefully, as planned, in October 1988. That will put the United States and all mankind in a position of knowledge that previous generations could never even have dreamed of.

Mr. NELSON. Is it true that the scientific community is unanimous in their support of these four great observatories?

Dr. EDELSON. Absolutely, Mr. Chairman.

Mr. NELSON. Let's turn to members' questions. Mr. Hayes.

Mr. HAYES. If you were addressing this morning a high school science class instead of this panel, which I'm not sure isn't a good way to think of me, what would you synopsisize? I say that for two reasons. One is I want you to know after the Wall Street Journal article that I know some big words, having been educated in the public schools of Louisiana, and secondly for the purpose of understanding where we are coming from and where you are going.

The reference to Hubble and the observatory program to me has a beginning, an end in mind, and steps for getting there. That is something that I am not sure I understand fully for all of NASA. Since you are leaving and can close the door behind you and they won't throw darts, describe for me, both within the space sciences and in a more broad brush, for a decade the beginning steps and end and goals both within your area of expertise and the NASA itself, if you were doing that description.

Dr. EDELSON. Thanks for asking the question, Mr. Hayes. I will try to do that. I have given some thought to that. I did have the opportunity to serve on the Reagan Transition Team for NASA when this present administration came in at the end of 1980, and during that time, this group examined the goal and role of NASA. Let me say I came from industry to take this position because of the excitement and challenge and value of the whole program, not just science and applications. And finally, over the last five years I have seen a lot.

There are a lot of top level goals, and I think right up at the top of the list you have to put pride in our country and prestige in the family of nations as a basic goal of the space program. Second, I think you have to look at the space program as a focal point and driver for science and engineering technology.

It is a way of gathering together to advance across a broad front in a highly visible and, as we proved in the last 28 years, very effective way of providing new knowledge, science and engineering, the development of technology that is used in the program, and stimulating thereby and advancing education of our young people, both because science and engineering then become glamorous, interesting and prestigious and because working on the space program—and I mean across the board, not only on the Hubble Space Telescope and the Galileo Mission to Jupiter but also on the Space Shuttle and the Space Station and other programs—puts those people at the forefront of knowledge and technology in the world and drives it ahead.

Now, within our Science and Applications program we have in every one of the seven disciplines that we follow developed a very comprehensive strategy, plan and setup of programs. We have

seven disciplines, to start with: astronomy and astrophysics, planetary science and exploration, solar-terrestrial science, earth science, life science; and microgravity science, with one pure applications area, and that is communications. Seven disciplines.

For each of those seven disciplines, we have got written down in a good fashion a strategy, a plan and a set of programs, and then we have an overall comprehensive plan.

I could go into each one of those, as I just did, let's say, for the Great Observatories, which makes a major contribution to Astronomy and Astrophysics, but you don't want to hear me pontificate, and besides we don't have the time to go into it. But it is, if approached comprehensively, a very exciting, thrilling and extremely valuable program across the board for the United States of America. I firmly believe that, and I have absolutely no regrets about being involved in that.

I am sincerely as supportive of every other part of the NASA program, the Shuttle Program and the Space Station Program, as I am of the Science and Applications Program, and I say that because there is a tendency to think, and even within NASA as we strive competitively for a larger share of the resources and so on, that the programs are not working together or are independent. They are very much interdependent and we are all working together.

Thank you.

Mr. HAYES. I want to thank you, too. It is very refreshing to see some enthusiasm—that I think many of us who are new members brought with us—nice to see that reflected within the agency itself, and it is a great loss, I am sure, that we will only have you back in the capacity as a witness not part of the NASA program.

Would I be correct in saying most everything you have told me boils down to one thing, and that is that science and technology has no nationalism and that whoever seeks it is going to find it?

Dr. EDELSON. Yes, I think that is correct. I believe what you are saying is that if we don't do it, another country can. There are allied points in here and it is sometimes difficult to discriminate them. We are very much interested and very supportive of international scientific cooperation. At the same time, we are very much interested and very supportive of United States technological competitiveness.

Those are not mutually exclusive. They go hand in hand. The best way to assert technological competitiveness and leadership is to be engaged in an international enterprise as the leader, and that is exactly what we are doing in the space program.

Mr. HAYES. No more questions. Thank you.

Mr. NELSON. Thank you for your refreshing honesty and your inquisitiveness. That is what is so refreshing, by the way, by going to elementary school classrooms. They are uninhibited in what they ask.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

I think my concern this morning would center around the budget considerations. Obviously, our programs and projects are driven by budget sometimes far more than we would like.

You have requested this year less than what was budgeted last year. Let me begin by asking: Do you see this as a trend that we will have to live with for the next several years?

Dr. EDELSON. Mr. Packard, I hope that it is not a trend. I could go over the puts and takes, which bring us some $45 million under. I think if you consider it a flat budget with the fact that the ACTS program has been left out, I think that is, without discussing that in any detail, the summary of it. We have always felt and the agency has tried hard to maintain an active, leading science and applications program, and to do that, they have always felt that science and applications deserves a fair share of the program. That has been quoted as a percentage at various times.

Mr. PACKARD. When you have to make cuts, how do you determine that? Who determines what projects stay, which projects will be cut? Does OMB give you a figure and say you have to come into this figure and you choose where you make your cuts? Do they cut certain specific programs that they don't want to see moved forward? How is it done?

Dr. EDELSON. We submit the budget from the agency in the month of September to OMB. Then OMB reviews the budget and never has, in my experience, ever added to it. Always in my experience it cuts out one thing or another.

Mr. PACKARD. They choose the projects to be cut?

Dr. EDELSON. Yes, they do, but they do that after we have had an opportunity to present and discuss at the working level the value and merits of each part of the budget. Then we generally get, usually around Thanksgiving time, usually on Thanksgiving eve, what we call a mark, which is a budget level lower than what we requested, with certain elements lowered or eliminated.

Then we have the opportunity to have a reclama for those items, and mustering all the arguments that we can, frequently, and let me say always over the last five years have been successful in reestablishing some but not all.

Mr. PACKARD. When you submitted your budget proposal—did you say August is when you normally submit yours?

Dr. EDELSON. Yes, sir.

Mr. PACKARD. In August——

Dr. EDELSON. September, actually.

Mr. PACKARD. September. How much did you submit for at that time for the 1988 budget year? Do you recall?

Dr. EDELSON. Yes. Almost exactly $1,600,000,000.

Mr. PACKARD. So it was an increase over what we expended last year in the 1987 budget year.

Dr. EDELSON. Yes, it was.

Mr. PACKARD. Or will spend. 1.6-what?

Dr. EDELSON. Right on the nose, $1,600,000,000.

Mr. PACKARD. So you were cut back close to $100 million.

Dr. EDELSON. Yes, sir.

Mr. PACKARD. In your reclama, you are attempting to reclaim or have you gotten approval on those that you are trying to reclaim from OMB?

Dr. EDELSON. This year the discussions had only to do with the new starts and augmentations that we were requesting and ACTS, so that we requested three new initiatives and we requested fund-

ing for the ACTS, and OMB gave us eventually only one new initiative and took out ACTS.

Mr. PACKARD. Were your three new initiatives in your original request of September?

Dr. EDELSON. Yes, sir.

Mr. PACKARD. So you didn't ask for any projects after OMB came up with their figures that were not in your original request?

Dr. EDELSON. No, I think that is not allowed at that juncture, to go back and think of new things.

Mr. PACKARD. I would assume you are right.

Did OMB request less than the 1.508 and that the reclama has added to OMB's figures up to 1.508?

Dr. EDELSON. Yes. The answer is yes, and I am a little confused as to the numbers here.

Mr. PACKARD. So you were successful in reclaiming some projects that brought it to your current proposal?

Dr. EDELSON. Yes. Specifically, the GGS program, which I put on the Vu-graph, was taken out in the initial cut by OMB, and through our reclama, we were able to restore the $25 million and the new start authority.

Mr. PACKARD. I guess the entire purpose of this line of questioning is to determine whether we have a priority system of including all of the things that you have on the last two pages of your submittal so that when we do have budget crunches or periods when we cannot fund all of the programs that you would like to fund, have we prioritized the programs where we would know in advance which programs would not be funded or would be funded at lower than what we would like? Or are we flying on a year-to-year basis, making those decisions on an annual basis in our jostling with OMB as to which projects we will and which we won't fund fully?

Dr. EDELSON. We have a very well-established, developed and documented plan, including priorities. Every year, however, in the budget submission we go in with those priorities and then we cut them out in reverse order. GGS is the sole survivor of the budget process, but if you will look at our priority new start list, it was at the top of the list. Next year we will have Comet Rendezvous Mission and AXAF at the top of the list for contenders.

So what you see is the result of a competition for scarce resources in the budget but based upon a well-developed, strategized, prioritized plan.

Mr. PACKARD. So if you found next year or in the 1989 budget year where OMB says you can't have any more than $1.4 billion, would you know at this point in time which projects are earmarked for reductions or eliminations? Have you prioritized long in advance so that you know which projects and programs will receive priority in the budget?

Dr. EDELSON. Yes, we do have that; although when you get a reduction or a cut in the budget not based upon individual projects, but just say cut to a certain level or cut some money out, you are forced to cut the programs that have money in the budget, which with regard to flight projects, are those projects which have recently been started and are building up.

Mr. PACKARD. I am sorry to take a little extra time on this.

Mr. NELSON. You continue. You have an excellent line of questioning.

Mr. PACKARD. I would like to extend it a little bit further. Now, you are competing for SR&T funds from other programs in your specific interest, the Space Program, the Shuttle Program, and a variety of other programs, the Space Station, et cetera. I am trying to see if we have some kind of a priority system where your competing for funds is equitable as others within our own department and within your interests competing for funds, or are we making decisions on a year-to-year basis as to how much money is going to replace Shuttle, to launch Payload, et cetera.

I am not trying to prioritize in my own mind where the priorities ought to be, but I certainly believe our experts ought to have some priorities so that we know as we deal with budget considerations what projects are less important to us if funding becomes a problem than other programs, and I would like it not only within these exciting exploration areas and planetary areas but competing with funds for hardware and for a variety of other things within the jurisdiction of this committee.

Dr. EDELSON. You are speaking of competition among the various offices of NASA for priority.

Mr. PACKARD. And within your own department of NASA also.

Dr. EDELSON. Okay. Within the Office of Space Science and Applications, my office, I have answered how we prioritize those through a program, and I am prepared to answer any questions on the priority of this program over that, but that is an extremely well-developed system which heavily involves our advisory committees. You will hear in a moment from Dr. Lanzerotti of Bell Labs who is the current chairman of our advisory committee, and it is through his committee that we come up with these priorities.

I believe I can say, as congressmen are wont to say without fear of being corrected, that we do have the across-the-board support of the space science and applications community for the priorities that we have established because it has been such a visible and open process.

Now, with regard to priority of programs within NASA, that is to say, the Science and Applications Program vis-a-vis the Shuttle, Space Station, the technology program and the aeronautics program, in general and over the years—and we have traced this out—we have gotten a fair share and it is clear that the Science and Applications program has done well when the agency has done well, and particularly tied to the manned spaceflight program, the science budget has done well.

At the present time, this year, we are in a singular situation where the agency has stated that getting the Space Shuttle flying again is its highest priority, and funding has gone preferentially to the repair and modification and establishment of construction of a new orbiter, with all of us knowing about it and with our general concurrence. Except for that, I think that within the agency we have all been treated fairly and gotten our share.

Mr. PACKARD. Mr. Chairman, I am out of time. I appreciate your consideration.

Mr. NELSON. We can take as much time as you want. Your line of questioning is excellent.

Let me point out to you that Chairman Roe and I have gotten together and sort of combed this budget and have come to some preliminary conclusions. As of this point, we are going to make some recommendations to the committee before we do the markup. By the way, the markup now is scheduled for the 31st of March. Originally we were going to do it on the 26th, and you guys have some trip to New York, so we rescheduled it to the next week.

We are going to recommend to you an increase over what NASA has requested of $255 million, which is still an amount that is less than the present year's budget. It is going to address such items as what we have talked about here. NASA came forth with this budget, for example, with no ELVs in the budget, and yet between now and 1995, in order to get up on what is on the shelf, over and above what the Shuttle can put up with four orbiters working, you would still have to have about 125 expendable launch vehicles.

So we are going to recommend to the committee three starts, only three, but they are critical and they go right to his programs. One is a Titan 3 to get up that Mars Observer that they have delayed, of which the Soviets are going to Mars in 1988. The Soviets have another mission that was scheduled for 1994 landing cameras with balloons on Mars. They have now accelerated that to 1992, and if there is ever going to be a lot of cooperation with the Soviets, we can't get behind the time line on this thing. So that is one of them.

Another one of the missions is another one of his programs, which is called the High Resolution Solar Observatory. It is going to be a program that will be attached to the Space Station, but you have got to get it started now. That is a $10 million consequence in this particular budget.

Another one is an ELV to get up a TDRSS 5. It is called the Tracking and Data Relay Satellite System. TDRSS is the acronym. We have to have sufficient number of them to be able to communicate all of this high rate of data that we are going to have coming from the Space Station. They don't have any provision for getting it up. We are going to provide a Titan 3 to get it up, and we are going to provide a third ELV in our recommendations to you of a Delta 2 to get up what is called a ROSAT, which is a Roengten satellite which surveys X-ray objects. It is a joint project with Germany. It again has been something which has been delayed and delayed and delayed.

So you can start to see how all of this integrates with his program. Dr. Edelson has been frustrated because of the crunch of the budget numbers, but we think that this just has such enormous consequence for us on down the line into the decade of the nineties that this is where we better look in the long term and not the short term.

All right. I think Mr. Konnyu is next.

Mr. KONNYU. Dr. Edelson, I visited the Lockheed Missiles And Space Company where the Hubble Space Telescope is, and looked at it. I don't know how you are going to get it in the Shuttle. It seems like it is as tall as this room is long. I was amazed at such things as the ability of that telescope to focus on a dime that in—if I may use a comparison—if the dime were in Boston and we were

in Washington, D.C., that space telescope could focus on that dime. I have no idea how you are going to do that.

Dr. EDELSON. And hold the focus for 24 hours.

Mr. KONNYU. Right. That is amazing. And then that evening after I had seen that space telescope, I reflected. You know, I am an accountant by background, a businessman, and I thought, well, what would my advisory committee that I meet with every other month—about 40 people, mostly business people although there are some academia and others in it—what would my advisory committee, Mr. Joe Blow, think about all this that we are doing in America through NASA, not just the Hubble Space Telescope?

One of the conclusions I came to is that they would be saying, okay, all that stuff is really nice, but what really leads to jobs, i.e., where is the real potential near-term, five-year lookout potential for commercialization, commercial use of the things you do? Maybe that JVX tilt rotor on the wall could have a commercial application, maybe a DOD application as well.

But within your area that we are discussing today, do you know of any of these projects which have some significant commercial potential within a five-year window?

Dr. EDELSON. There are many ways to answer your question. One is to point out that we have an applications program within Science and Applications which is aimed at developing the practical aspects, and in the past it has been responsible for developing the communications satellite and weather satellites and other earth observation satellites, and is now engaged in continuing all these and working upon direct applications in microgravity, studies of what can be done in low gravity on the Shuttle and the Space Station, and development of the medical aspects and so on.

Another area not realized very much on which we have just completed a study is the identification of the technology that comes from major projects like the Hubble Space Telescope and like Galileo: for example, the technology that allows you to point the Hubble Space Telescope to stay on a dime from here to Boston, or another analogy I used the other day is it would allow you to swish a basketball through the hoop from here to San Francisco. It is that type of accuracy.

Mr. KONNYU. Tom McMillen is not here.

Dr. EDELSON. Right.

Mr. KONNYU. But he will sure be impressed by that example. [Laughter.]

Dr. EDELSON. It is very impressive, and the significant point is that that technology is brand new technology. It is leading edge technology. It puts the United States—that is rare nowadays—way ahead of what any nation can do, and that particular technology now resides at the Lockheed Missile and Space Company and at Perkin-Elmer Company.

Mr. KONNYU. Does it really? Isn't that open for anyone to use, so it is not a patented technology but an open access technology?

Dr. EDELSON. From a legal point that is true, but what I am pointing out is that we now have the technology. We have not only the intellectual data that one sees in terms of patents and drawings, but we have the machinery and the knowledge and the minds

of people and the skilled engineers and the skilled workers to do that.

We have just completed a study, which I will be delighted to provide to the committee over the next couple weeks as soon as it is printed up and available, on an investigation of those two projects, the Hubble Space Telescope and the Galileo Mission to Jupiter, an analysis of "Incidentally, what technological developments were made?" not because those are technology development projects—we are not aiming at developing technology per se—but incidental to solving the great problems.

For example, on the Hubble Space Telescope we made major improvements at the Boeing Aircraft Company, a subcontractor to Perkin-Elmer, in design and fabrication of the focal plane assembly and the metering thrust in graphite epoxy structures. That is a basic structural material and capability. We improved the material, its strength/weight ratio and its thermal characteristics. We improved the design. We developed a new software design technique. That technology was brought about not because anyone was interested in doing that but because that was necessary in order to develop this very fine optical instrument.

Now, that technology resides right here in America, and it can be used for every purpose. It obviously will be used at Boeing in aircraft structures, but it will also find its way into everything from automobiles to fishing poles because it is a basic structural material and concept.

Mr. KONNYU. So you don't have a specific application that could be commercialized within a five-year time frame that you know of, but the——

Dr. EDELSON. I'm sorry. I guess I could be accused of avoiding your question. Let me land quite directly on the Advanced Communications Technology Satellite. It is a satellite designed specifically to put the United States years ahead of the technology of Japan and Europe. It is absolutely vital and of extreme importance to commercial and other communication satellites. It will keep the United States years ahead of other countries in this already very sizable and profitable commercial market, now measured at something like $5 billion per year, and all commercial money.

Now, this is recognized to be so commercially viable that we have the difference of opinion between the Administration and the Congress which we are all aware of. The Administration is saying, hey, look, this program is so commercially viable and so important and so valuable to industry that they ought to pay for it, and the Congress has said each year: we agree it is valuable and useful and commercially viable, but we think that the government should pay for it.

I have been for the past few years somewhat of a ping-pong ball in that argument, but it illustrates perhaps more specifically than anything else I can say the recognition of how commercially important and useful space technology can be.

Mr. KONNYU. Dr. Edelson, let me then conclude this line of questioning by a simple statement, which is that I think it is important that, besides the notion of pride in America, of leading in these technology fields, which is, of course, important to all of us both in terms of good feeling and for really leading in the future, these two

examples that you cited, I think, are important elements that should be featured whenever you discuss these issues with the public because they sort of bring reality into the picture and show the relationship between hope and quest and near-term achievement. That relationship, I think, creates a glue around which your program could get even greater support. That is just my little addition.

Dr. EDELSON. Thank you, Mr. Konnyu. I appreciate that.

Mr. NELSON. Mr. Konnyu, your district is Silicon Valley, isn't it?

Mr. KONNYU. That is right.

Mr. NELSON. You are aware that it was actually the computational requirements coming out of the space program that in large part built all of that industry that is out there in your district.

Mr. KONNYU. I hope to tell you.

Mr. NELSON. And the Lockheed plant that the Hubble Space Telescope is being managed through, that also, I think, is in your district, is it not?

Mr. KONNYU. That is correct, as well as Ames.

Mr. NELSON. Let me point out that, following up on Dr. Edelson, he can speak with a little bit more candor, perhaps boldness, because of the fact that he is en route to private enterprise, but this ACTS thing has been going back and forth as a ping-pong, and there is generally a unanimity of feeling that this is a system that we need to press, to develop. It is going to be an extraordinary new kind of communication. It will have commercial application.

It, as so many other things, can private enterprise develop by themselves. We have gone through all of this nonsense in a debate with LANDSAT: can LANDSAT be commercialized? Yes, it can be commercialized. Can private industry make a profit by paying all the costs of building future LANDSATs and then sell the data and without any government support? That is questionable. But because of that debate, we have been slowed down and slowed down and slowed down, and LANDSAT is in its last gasp, in the death throes right now unless it can be resuscitated by the CIA.

That is exactly what we are going through right now, and it is just a sad thing that you have to go through that. The same kind of question came up on the question of the replacement orbiter. Can you make it commercially viable? Can private enterprise pay for it? Now, because there were members on this committee that felt strongly about that, I decided that the important thing was to keep the replacement orbiter going and leave open the question of how do you finance it, although I was pretty sure that no private enterprise was going to be able to come forth with a viable funding of $2.1 billion, running in that kind of high risk environment up there, that was going to make it a profitable enterprise.

So here we come again to another ping-pong match of can ACTS as this advanced communication technology be commercially viable so that private enterprise can go out and build it? Basically, this committee has taken the position that no, it can't. So in that $255 million that I am likely to recommend to this committee at the end of this month is an item of $75 million to continue ACTS.

Now, we paid a lot for ACTS already because this has been an appropriation over the course of the past three or four years, but

again, the issue has been framed very well here and I wanted to take the opportunity to expand upon it.

Okay, let's see. Who is next on the list? We have Mr. Perkins.

Mr. PERKINS. Thank you, Mr. Chairman.

Doctor, I have just a few brief questions, if I could. I have been concerned about the depletion of the ozone through the hole down at the South Pole, and I know we have a lot of studies going on presently. What is the budgetary prognosis in terms of that situation? When can we expect some sort of preliminary report as to results going on in testing that is going on?

Dr. EDELSON. As you may know, Mr. Perkins, we are conducting those studies as part of our ongoing research program. The measurements have been made largely by an instrument on the Nimbus 7 satellite, which was launched nine years ago. In this program we have been working very closely with the National Science Foundation and with NOAA to have a comprehensive study.

What Mr. Perkins is asking, Mr. Chairman and others, is a question of when we will get enough information to understand the phenomenon, presumably, and be able to tell of what significance it is. It obviously is significant.

Mr. PERKINS. It is a new phenomenon.

Dr. EDELSON. We have always known that there is a variation on an annual seasonal scale of ozone in the upper atmosphere in various places. What is new and observed only since the late seventies is a significant depletion of ozone above the Antarctic in the Arctic winter, which is September-October time frame. We measured it at first casually, and as we began to notice it, we measured it with precision and we sent a special team under Dr. Susan Solomon to review that recently.

We are not able to determine with the present knowledge whether it is continuous or reversible or cyclical, and we do not know whether the cause is dynamic, chemical or solar induced, and we are going to have to study it for a period of time. If it is continuous and spreading, then it is indeed extremely serious, but the scientific community is by no means sure of that. There are those major questions which have to be answered by ongoing scientific research, and we have in our existing program and in our future program plans to instrument and study that intensively.

Mr. PERKINS. Fully realizing that it is impossible at this stage to give some sort of an idea as to exactly how all the long-term studies go on, but when can we expect some sort of a preliminary report on that?

Dr. EDELSON. There is a very comprehensive report coming out now of the accumulation of knowledge, but it will have the speculations about its cause and general trend in it.

Mr. PERKINS. Essentially are you getting a year-by-year—

Dr. EDELSON. I think it will be two to three years before we can begin to shed light on that. As Mr. Keller pointed out—I will let him point it out himself.

Mr. KELLER. Mr. Perkins, I was just going to add that the next major activity we have planned will be an expedition to the Antarctic next fall, where we will utilize the DC-8 and the U-2 to make in situ measurements throughout that region.

Now, whether or not we will gain sufficient information as a result of that expedition to make any kind of a definitive observation, I don't know, but it would be reasonable to expect that after we assimilate that data and we assess how it impacts our present theories, we may be able to come up with something. So I think Dr. Edelson's few year estimate is probably the most reasonable time at which you could expect to get an answer.

It was also whispered in my ear that the Upper Atmospheric Research Satellite (UARS), which is also being worked on right now, should be a major contributor. So there are any number of activities that will produce new data. To speculate on when we have the definitive answer is a lot riskier, but we are moving ahead as rapidly as possible.

Mr. PERKINS. Just briefly so I won't take too much of the committee's time, in terms of the El Nino event, what types of studies are being done that we can lay our hands on to just take a look at some of those studies there that are going on presently?

Dr. EDELSON. I would like to ask Dr. Shelby Tilford, who is Director of our Earth Science and Applications Division, to answer that because that is kind of a comprehensive question and requires a similar level of answer.

Dr. TILFORD. There are, of course, a number of programs laid out to look at the El Nino. One of them is the Tropical Oceans and Atmosphere Program, TOAP, which is a cooperative effort between NOAA, the National Science Foundation, and NASA. Furthermore, with programs like TOPEX, which you approved last year, which will precisely measure sea surface elevation, and the Scatterometer, which will accurately measure sea surface winds, we hope with the development with the next or the next two El Nino effects, that we will be able to understand much better the cause and effect relationship.

What we are lacking, especially in this part of the world, is data, so it is very difficult with the existing ship-borne observations, which are only scattered very sparsely throughout this region of the world, to observe on any kind of continuous basis what the cause and effect relationships are.

With the global observations, which will be complemented by the ongoing NOAA meteorological satellites, we hope that with the advent of the next El Nino, whenever it takes place, and right now they occur approximately every seven years with some sort of randomness, so plus or minus 7, that we will be able to study this in much more detail than we ever have in the past.

So hopefully, within the next two cycles of having these global observation systems up, we will be able to understand better what the cause relationship effects are, and especially the impacts. That is one of the biggest problems, of course, based on our experience with the last El Nino, which is one of the larger ones.

Mr. PERKINS. So you think it is going to take two cycles?

Dr. TILFORD. I think it will take at least two cycles. With the satellite complement that we are talking about not being launched until the early 1990s, we may very well have one more cycle before the total observing system is available, and then it will take at least one after that.

Dr. EDELSON. I can't resist the opportunity, Mr. Perkins, to point out that your questions have elicited answers which indicate the extreme importance and reach of our space and earth science program. I think that NASA, the U.S. Space Agency, is really leading the world in earth science. We are charting new courses and in an absolute leadership position in oceanography, and an understanding of the climates and all these interactions, the depletion of the ozone layer and the El Nino effect and what its cause and effect are having are all an outgrowth of the space science program in which we have the vantage point of space to make the comprehensive and synoptic measurements that allow us to do all this.

Mr. PERKINS. Mr. Chairman, one more question.

In terms of the Hubble Space observatory and some of the different great observatories that you were talking about earlier, what are going to be some of the initial focuses of experiments that you will be trying? Will you be looking at quasars, what type of things initially are you going to do?

Dr. EDELSON. Again to allow the person who has the authentic answer, let me turn to Dr. Jeffrey Rosendhal, who is in a position to give us a lot of background on that.

Dr. ROSENDHAL. I think the simple answer is that the Hubble Space Telescope is being designed as a true observatory with a range of focal planed instruments, including two spectrographs, two cameras and a photometer to carry out studies of a whole variety of objects. So we expect that the telescope will be used for studies of everything ranging from solar system objects—and it is a little mind boggling to realize that we will see the same image clarity from the earth orbit with the telescope at Jupiter that we saw from the Voyager ten days out—to be able to do synoptic studies of Jovian meteorology all the way to observations of the most distant quasars with perhaps all stops in between.

I think that one thread or two threads that are going to be particularly important for the Space Telescope observations are going to be to establish the cosmological distance scale. To really narrow in and vastly increase our understanding of the scale of the overall universe to be able to use indicators in distant galaxies that we can only use now on our local neighborhood of space as benchmarks for establishing that scale.

I think a second problem, one among many that will be a hallmark of the program to be carried out with the telescope is to understand the evolution of galaxies themselves. If you characterize the nature of astronomy perhaps during the first half of the 20th Century, what you see was a vast increase in the understanding of the nature and evolution of stars. What we are going to be able to do is extend those studies to the larger assemblages of stars, which seem in a certain sense to be the basic building blocks of the universe, namely, the galaxies, and get a hand-hold on understanding what drives the evolution of an entire galaxy. What are the structures? What are the forces? What are the differences. Why are different kinds of galaxies having different forms? And what is the overall evolution of these very basic building blocks?

So we are going to study just about everything, literally, under the sun that you can think of, from the solar system itself out to the furthest reaches, with this very general purpose observatory.

Mr. PERKINS. Mr. Chairman, I thank you for your patience, and I would like to compliment you on your support for the Mars Observer, which I think is absolutely crucial in getting to where we need to be.

Mr. NELSON. Well, you are welcome to take as much time as you want. That is what we are here for.

Mrs. Morella.

Mrs. MORELLA. Thank you.

I also want to congratulate NASA for having the expertise and enthusiasm of Dr. Edelson and the rest of the panel who are affiliated with the whole space program.

My question has to do with the Mars Observer because I notice, Dr. Edelson, that in your presentation booklet here, that again it goes back to the 1992 launch rather than 1990, and I wondered if the launching in 1990 is predicated on what our chairman has said about advancing additional monies for the Titan-3 to launch it in light of what the Russians have indicated, the Soviets, in terms of going to Mars. What has that done to our program?

I am saying to you that I am confused because one moment I hear NASA is going to try to do it in 1990, and then I read, well, 1992 is still the date, and then I hear our chairman talking about what we need for it.

Dr. EDELSON. The answer to your question, Mrs. Morella, is that first you must understand there is a 26-month gap between opportunities to launch to Mars. Second, when we prepared the budget in August, before the manifest was made up and before the mixed fleet study on ELVs was completed, we examined the possibility of launching four missions—Magellan, Ulysses, Galileo and Mars Observer—in a two-year time frame, and concluded that that was not possible.

So, reluctantly we took the money out of the budget, and we are talking about a sum of some $50 million that we removed from the 1988 budget.

Mr. NELSON. Now, explain how that was not possible. You are talking about you couldn't launch four on the Space Shuttle.

Dr. EDELSON. On the Space Shuttle in that time.

Mr. NELSON. She needs to know that.

Dr. EDELSON. We could not launch four with all of the preparations and difficulties of mounting these complex planetary launches on the Shuttle, with the uncertainty as to how fast we would be able to launch them and so on, in that time frame. So, reluctantly we took the money out of the budget. However, wisely we did not delay the development of the spacecraft, so at this moment the spacecraft is being developed by RCA Corporation—I should say General Electric RCA—on a schedule which will allow it to be launched in August of 1990. But we do not have, and that is the point in my opening remarks, the funds, amounting to about $50 million, in our 1988 budget that would be required to keep it on schedule.

Since August when we prepared the budget and submitted it, we have published a Shuttle manifest, we have completed our initial analysis as to the Mixed Fleet Study, we have had extensive discussion with manufacturers and with the Air Force about the use of expendable launch vehicles, and we now understand that the Mars

Observer could be launched on a Titan-34D first stage with a TOS upper stage, and they would be available in 1990.

Now, as I have heard Dr. Fletcher say several times, it is "only" I think you have to put quotes around that—it is "only" a question of money, money to keep the development on schedule and money to procure the Titan launch vehicle.

It is not more expensive all together. In fact, it is a considerable saving to the taxpayer, all things considered, if we launch in 1990 rather than 1992, but we don't have the money or the ELV in our plan and in our budget now when we need it to be able to do that.

Mrs. MORELLA. You mentioned that you found that you could do it with the Titan-34D, with the TOS, et cetera; is that correct?

Dr. EDELSON. That is correct.

Mrs. MORELLA. But you don't have the money to do more with that?

Dr. EDELSON. That is correct. We do not have the money in the Mars Observer development schedule, development plan, and we do not have a Titan-34D on order to launch it.

Mrs. MORELLA. You do not have. I understand.

Mr. NELSON. Would the lady yield?

Mrs. MORELLA. Yes, indeed.

Mr. NELSON. What, in effect, in that number crunching that goes on over there at OMB, they cut NASA way down to something like $7.75 billion, and Dr. Fletcher made an appeal and got it back up to about $9.5 billion. But in all the things that they want to do, they did not take that step to start providing for ELVs, and that is where one of those four planetary missions has to fall through the cracks, because they don't have enough space on the Space Shuttle, and we are assuming that the Space Shuttle is going to be up and running early in 1988.

There is another question. What happens if you get a major delay in the Space Shuttle? Then other things start to fall through the cracks. But here is an interesting point, and this is why I asked you to yield. With each of these major satellites like the Space Telescope, there is a cost just to keep it on the ground. You heard Dr. Edelson say that just to keep all the systems up, the computer software checked out, the scientific team together for the space telescope is $6 million a month until we can launch it.

So too on the Mars Observer. The cost is generally in the range of $4 million to $6 million a month. So when we look at what are the dollars to the United States of America, there is a cost in delaying that Mars Observer for 24 months, just to have it sit on the ground, of some $4 million to $6 million per month.

So the question is, is it better in the interest of the nation to keep it on schedule and go ahead and pay the money up front and buy an ELV, a Titan-3, of which one the Air Force has told us is available, or to let it sit around and cause those costs to occur between 1990 and 1992 and therefore keep your budget down in 1988? That is the question facing us.

Mrs. MORELLA. That is fascinating accounting because you are saying that by putting the money in now, you are going to save so much money that this is a cost saving device as well as keeping something on target. Thank you.

Mr. NELSON. Not to speak of the science that we are going to get two years early by going ahead and launching it. But that is what makes our job interesting.

Mrs. MORELLA. I try that accounting at home all the time. [Laughter.]

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. I was just thinking the chairman should go shopping with my wife. I could not figure out how to spend all the wealth I would have. [Laughter.]

I was looking at your testimony, and I have a concern. I don't fault you for it, but I noted that Ulysses, for example, was originally scheduled for May of 1986, was postponed due to the Challenger disaster, and current plans now call for launching it in September or 1989 or October of 1990. The Galileo was scheduled for launch in May of 1986. The Challenger accident caused postponement, and it is now set further back down the road. The Hubble Space Telescope the same.

What plans do you have to keep these projects on line if the Shuttle is delayed?

Dr. EDELSON. We have worried about that considerably, Mr. Nagle, and of course, the number of missions that we have, which is, if you will look at the manifest, about 40 Space Science and Applications Shuttle payloads between 1988 and 1995. Of those 40-odd missions, they are on the average delayed three years, and some of those, it would break your heart.

For example, you mentioned Galileo, and I can hardly talk about it without tears coming into my eyes. Not only is the launch delayed three years, at least, but the trip to Jupiter is increased so that it will probably be, it has been pointed out to me, about 20 years from the start of the science program until the realization of science data.

That number of 40-some launches is planned for the Space Shuttle. If the Space Shuttle fails to meet its commitment in any significant way, I am afraid that those missions will be decimated because there are higher priority missions on the manifest. We are terribly concerned about that.

We are and I have been personally very interested, and I have even been called enthusiastic about the use of expendable launch vehicles, but we are only talking about seven Space Science payloads, not seven Shuttle loads, but only seven Space Science payloads that make any sense, which is equivalent to about four Shuttle payloads. So out of the 40-some, not more than 10 percent could under any circumstances be launched on ELVs.

Now, that is a long answer, Mr. Nagle, which says that we are very dependent upon the Shuttle. Whatever we say about expendable launch vehicles, we are praying, hoping, depending upon that Space Shuttle to be up and operating again with a high degree of reliability.

Mr. NAGLE. I don't mean this critically at all, but do you have any thoughts in terms of what this committee could do or what the space community could do to avoid hoping and praying, in terms of alternatives that we could consider to anticipate? To me what we are doing is we are making almost the same—not the same mis-

take, but to me, we are putting all our eggs in one basket in a very, very high risk game, which is space.

You know, we found out the first time when we had a disaster—and I'm not talking disaster, I'm not entertaining that thought, I'm just talking delay. Is there a way around that? Can we bifurcate the program? Can we build contingency plans? Has that alternative been considered by the Agency? Has the Agency got any plans or thoughts on it you would like to share with us? Something so that we just don't have to hope and pray?

Dr. EDELSON. Yes. The Agency has really gone through a significant change in its view on the use of expendable launch vehicles. I think it is fair to say that from Dr. Fletcher on down, and now including myself and Admiral Truly and the whole group, we now realize that the Shuttle is of overwhelming importance but there is also an important role for expendable launch vehicles, and that we must in the future—and I think this is the new view that is generally accepted to the maximum extent with our existing programs—but in the future use the best vehicle for every mission.

For those missions that require manned space flight, obviously you use the Shuttle, and for those missions that don't, you use expendable launch vehicles. The Agency is planning to do that, and after the early nineties, I think that we will be able to do it, but for the next few years, we are in a bind, and I think the discussion that is now going on as to how we will be able to launch Mars Observer and the other space vehicles is important.

Now, specifically, Mr. Nagle, we have requested—and that is what you are seeing now—the use of a Titan-34D, sometimes called just the Titan-3, for the Mars Observer. We have also requested a Titan-4 Centaur vehicle that would be used in the event that any one of the three—Magellan, Ulysses, Galileo—is unable to be launched on the Shuttle at their launch windows. In the happy event that we all hope for, that all three can be launched on the Shuttle, we would then use the Titan-4 Centaur to launch the Comet Rendezvous/Asteroid Flyby Mission, the so-called CRAF mission, which is our top priority new start.

Mr. NELSON. Would the gentleman yield right there?

Mr. NAGLE. Surely.

Mr. NELSON. That is something we didn't know. When did you request a Titan-4?

Dr. EDELSON. That is an internal request. It appears in all of the Agency presentations which most everybody has seen on the Mixed Fleet Study. The status of the Mixed Fleet Study, the study of what the Shuttle can do and how the ELVs can do and how to match it up, that has not been officially released at NASA because we don't have all the conclusions and we don't have a complete plan for implementing it. However, the results of the study have been briefed around town, and in that study——

Mr. NELSON. Could you brief us?

Dr. EDELSON. I will give you a piece of paper in a minute that has it all written down on it, but basically, we have identified seven missions, including COBE and Mars Observer, which you know about, and also including the ISTP missions which we discussed earlier, which are those that make a lot of sense to launch

on ELVs, and in addition to that, we have requested one Titan-4 Centaur as a planetary backup for CRAF, as I point out.

Now, when I say we have requested, I mean that my office has requested of Admiral Truly's office to put that in the plan. Admiral Truly's office has gladly accepted that request and is trying to honor it.

Mr. NELSON. When does the budgetary consequence hit? You put it in the request for what year?

Dr. EDELSON. We are in the budgetary problem right now with regard to the Mars Observer and ROSAT. Those are specifically the ones you mentioned. The other ones are longer range.

Mr. NELSON. So you are saying you would want this Titan-4 to start in fiscal year 1988 as well?

Dr. EDELSON. I can't answer that question because I do not believe that it is a question of any significant amount of funds in 1988. I think it is a question of a long-term commitment that the Agency would make for launches which might occur in 1990 or 1991.

Mr. NELSON. Well, a Titan-4 is not going to be ready by 1990, so you are talking about 1991 or 1992.

Dr. EDELSON. That is correct.

Mr. NELSON. And you are saying that there would be actually no consequence in fiscal year 1988. The consequence of those three other ELVs, two Titan-3's and one Delta-2, is $100 million. That is what it adds up to that is going to be my recommendation to the committee over and above what you requested.

Dr. EDELSON. Mr. Chairman, I can't answer to the dollar amounts because what we are talking about is the payment that would come due in 1988 on various kinds of procurements, some of which we would get through the Air Force and others perhaps we would get directly, and furthermore, I just don't have the numbers, although we would be glad to submit those.

Mr. NELSON. All right. We are having Admiral Truly here on Thursday, so would you ask him to be prepared to answer that question?

Dr. EDELSON. Yes, sir, I shall.

Mr. NELSON. Thank you for bringing that up.

Mr. NAGLE. I would like to go a little further if I could, Mr. Chairman. I guess I would have a little more faith in the contingency plans if you had requested the three ELVs rather than the committee sub spontane, you know, putting them in for you. But it seems to me that we are at a very critical time right now because we are planning the budget for you a year after the disaster, and I hear around town, to use your phrase, that February is the optimum date for the Shuttle launch and that there are many that think that, in fact, that date could be delayed.

Do you hear that around town, too?

Dr. EDELSON. I have heard rumors of that, but I have been a party to the top level meetings within NASA of the Administrator and all of the top level officials, and I am convinced in my own mind that February of 1988 is a doable date, that we are on top of the engineering, that we understand what we are doing, and I could only say that if I were the Administrator, that is the course I would be on, and I think the Agency is doing exactly right pushing

for that, and if we can all get together and work on it, we will have it, and we all need it, particularly my question.

Mr. NAGLE. Yes. I don't ask you these questions as an adversary, but has there been within your agency or within NASA any review of alternatives that we could use other than simply relying on the Shuttle, other than the seven that you mentioned—could I ask you what those seven were, by the way, just for the record?

Mr. EDELSON. Yes. That includes COBE, Cosmic Background Explorer, which we have already arranged; Mars Observer and the X-ray Satellite, known as ROSAT; FUVE, which is an Explorer, Ultraviolet Explorer; and three ISTP satellites known as Geotail, Wind, and Polar.

Mr. NAGLE. Why not the TDRS's?

Dr. EDELSON. The TDRS's are not in my program. The Agency——

Mr. NAGLE. When you say 40, then, the only 40 you are talking about are within your program?

Dr. EDELSON. Yes.

Mr. NAGLE. How many total are we talking about in terms of all the programs, and how many have we delineated out that we could use ELVs on?

Dr. EDELSON. The TDRS is the only one that I know of—in fact, I am looking at the Agency's chart—of the NASA missions. There are two TDRS's with the option of a third one that could go on ELVs if they were available and if we had the money to pay for them.

Mr. NAGLE. Now to complete the question, and I think this is the last one I have, has there been any Agency studies, either under your direction or anyone else in the Agency, over the feasibility of bifurcating the risk between ELVs and the Shuttle? Am I clear?

Dr. EDELSON. Yes. It is possible to prepare spacecraft for launch to be dual compatible so that an individual spacecraft could be launched either on an expendable or Shuttle, and that is completely possible and easy for a small satellite like a communications satellite. It becomes very difficult and very expensive if it is a large spacecraft: for example, one of the Great Observatories or the UARS, Upper Atmosphere Research Satellite and so on, which are built in a certain way simply to go on one vehicle or another.

Mr. NAGLE. I am sorry, I am new here and my questions probably show it, but has that information been presented to this committee?

Dr. EDELSON. Not explicitly, but I think the staff members like Dr. Smith have been over and reviewed all this data and it is in there.

Mr. NAGLE. Explicitly, though, has it been furnished to the committee?

Dr. EDELSON. It has not, to my knowledge.

Mr. NAGLE. Then I am sorry for one last question, but are you comfortable professionally with putting the amount of risk we have on timely Shuttle flights? I want the Shuttle to work and I support the Shuttle, but do we have too many eggs over there?

Dr. EDELSON. Mr. Nagle, we are all in a very uncomfortable position, and I believe I could not in good conscience say that I am comfortable with the situation, but the statement I will make is

that I feel that the Agency is doing all the studies and receiving in fairness and good grace all of the requests that I have made and that my various program managers have made for studies of alternatives.

I think we are doing the best thing now. If your question were to——

Mr. NAGLE. It is troublesome, isn't it?

Dr. EDELSON. Well, it is troublesome only to the extent that you have asked the question with hindsight: would we have planned to launch differently?

Mr. NAGLE. No, I am asking for March 3, 1987, the budget you have submitted that we have seen. What would it take to make you more comfortable with the amount of risk that we are putting in just simply using the Shuttle?

Dr. EDELSON. I have difficulty using the word "comfortable," so let me substitute "satisfied." I am satisfied that we are in those cases in which we can do anything, we are.

Mr. NAGLE. Let me substitute the word "pleased." [Laughter.]

Dr. EDELSON. That's worse. I don't mean to fence with you, Mr. Nagle; quite the contrary. Let me repeat the statement that only a few of the 40 Shuttle launches, about four Shuttle launches, would make any sense to consider launching on ELVs, and those four Shuttle launchfuls, which is exactly seven missions, we are requesting that be switched to ELVs, and that is in process now.

Mr. NAGLE. When do we get that information?

Dr. EDELSON. I will provide it immediately.

Mr. NAGLE. Last question. What about the other missions in the other departments? Are their recommendations going to be forthcoming to us to switch some of those to ELVs, do you know?

Dr. EDELSON. Yes. You will have to ask Mr. Aller, but I think that it is clear from the Agency papers that there is only one other mission that could switch, and that is the TDRS missions, the three tracking and data and relay satellites.

Mr. NAGLE. Would the switch enable us to maybe make up some ground on some of these projects in terms of the time delay?

Dr. EDELSON. Yes, absolutely.

Mr. NAGLE. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON. I appreciate your perspicacity.

Mr. NAGLE. What does that mean? [Laughter.]

Mr. NELSON. That means that you are a bulldog.

There was a clue that Dr. Edelson gave a while ago in some of his answers when he says internally they are actually making a recommendation on a Titan-4 as another backup. I mean you can only get so many payloads on the Space Shuttle and it can only fly so many times, so the sad fact is there are about 125 ELV loads-worth between now and 1995 over what we think that the Shuttle can deliver to space, so you are right on.

Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

I am going to follow on the same line of questioning because I think this committee has some real concerns, and part of it stems from mistakes that all of us made just a few years ago. And when I say all of us, I mean to include this subcommittee and this Con-

gress and NASA when we moved away from the mixed fleet of vehicles. I think we know in retrospect now that we would be far better off if we had a viable commercial industry out there with ELVs available that you could be purchasing right now for those payloads rather than trying to put that in place at the same time we are trying to recover from a Challenger disaster.

You don't have to comment on that, but I think it is as clear as the nose on our faces that that is the case right now, and it seems to me that it is also important for you, though, to make clear that it is extremely important to the science programs to have a viable commercial ELV industry in the future, isn't it?

Dr. EDELSON. I agree that it is very important to have expendable launch vehicles available for the science program.

Mr. WALKER. And the way we are going to get that is through a viable commercial industry; isn't that right? I mean do you see any chance that we are going to have the kind of funding in the NASA budgets in the future that is going to allow us to purchase the numbers of ELVs as vehicles and purchase all of the launch services and so on to go along with that that will even cover your missions let alone all the rest of the things we have to do?

Dr. EDELSON. I really can't answer that, Mr. Walker, because it is a matter of policy. In my program office I would be pleased to have the ELVs available through the Air Force, through a commercial organization or through a NASA procurement through Admiral Truly's office.

Mr. WALKER. So in other words, what you are saying is that it is very important to this country to have the ELVs available to us at this point?

Dr. EDELSON. Yes, sir.

Mr. WALKER. And as we look into the nineties, throughout the nineties, that is going to be true for the next decade or more?

Dr. EDELSON. Absolutely.

Mr. WALKER. It is particularly important, I think, when we begin to put this business of the Shuttle launches together with the needs of your program because aren't a number of the launches that you are counting on out through the next five to ten years predicated on the idea that the Shuttle will be flying 16 times a year?

Dr. EDELSON. The Mixed Fleet Study, which I will provide the results of with this material, assumes two cases, and that is that we build up to the rate of 16 per year, and another case where we build up to 12 per year.

Mr. WALKER. We would be interested in seeing both of those aspects because what we are hearing from the witnesses from NASA who come and testify to us is that they are still making their plans around 16 a year. What I would be fearful of is that as they are then presenting it to you in terms of the launches that might be available for your programs, that your programs are based upon their calculations that they can, in fact, fly 16 a year.

I think there are a number of us on this committee who have reasons to doubt that we will ever achieve that flight rate even if we—certainly we are not going to achieve that flight rate with three orbiters, and there is some question in many of our minds as to whether or not we will ever achieve that flight rate with four orbiters.

Dr. EDELSON. Yes. The questions that you are asking about the feasibility of doing it are properly addressed to Admiral Truly, not to me.

Mr. WALKER. I understand, but it is extremely important when you tell us that there are only seven payloads or four Shuttle bays out of the 40 that you need to launch that you can put aboard ELVs, and then we begin to understand exactly what the capacity of that Shuttle system is and that that capacity is somewhat different than what we are seeing projected in your program and in others. I have got to tell you that we see ourselves coming up against the same crunch again that we have faced in the past.

Here is my problem. That comes out of the hide of your program. It is reflected in this budget and it is reflected in everything that NASA is doing right now, that we are taking it out of the hide of the science programs. I have got to tell you that when I look down through the budget priorities reflected in this budget and see that you are down in terms of real dollars and down in terms of the percentage of the NASA budget, that tells me something very disturbing.

From my perspective what it tells me is that NASA is in the process of losing its way because it was put together as an R&D agency. An agency that was supposed to be on the leading edge of things, and in one of its most leading edge programs, that is where it is pulling back. What we are ending up doing, then, is taking the more expensive programs out of your hide.

What I am telling you is that when I see the Station come in here and we are going to double the cost of the Station, I know exactly where they are going to find that money if, in fact, we approve it. They are going to find it by taking it out of science, and we are going to find all of these things coming out of the hide of our most forward-looking programs.

Is any of this being talked about in the Agency?

Dr. EDELSON. Yes, indeed, Mr. Walker, we are very much aware of that and discussing it at great length. It is difficult for all of us to maintain the balance that we would like to maintain.

Mr. WALKER. But the recommendations we get from you go precisely in the direction I am just talking about, so what you are saying is that it is very difficult but you lost.

Dr. EDELSON. As I said in my opening statement, and I am reluctant to go any further than that, we have suffered a great deal from the hiatus due to the Challenger loss, from the slow buildup and from the cancellation of the Shuttle Centaur program. That is costing us a delay of three years and it is costing us a great deal of money to keep our program going, all of which we are doing on a level budget.

I find it difficult to say more in that my purpose in being here today is to support the Agency's budget request which is before you now and which we have worked out internally to provide what we believe to be the appropriate balance.

Mr. WALKER. I understand that you are in a very difficult position, but we also are in a difficult position. I think a number of us have the feeling that there is something going drastically wrong during this period when there are a lot of problems, we understand, with budgeting at NASA. But if the priorities that the

Agency is bringing to us don't seem to go with the priorities that we see this nation having to pursue to be in a place to really have a space future for this country, then we are probably going to have to readjust those priorities.

I guess what I feel is that we have got to hear from some of you what it is that we need to do in terms of that readjustment. You know, it is perfectly appropriate for you to come up here and defend the numbers the Agency came up with. That is your job. It is also appropriate for us to have all of the facts at our command if we decide to readjust some of those priorities in a way that makes more sense for the space future that we envision.

The questions that I am asking are based upon that kind of feeling, that I think your budget is going to be changed in this subcommittee. Now, what do we do to make it work better? We don't want to go back to where Congress and NASA makes the same kinds of mistakes that we did when we backed off the mixed fleet. My guess is that had we committed ourselves to a mixed fleet back in the late seventies and you were planning these science programs then, that you would not have planned to fly them aboard the Shuttle if you had had another availability because that manned interface is extremely expensive. So you get less science for the same bucks if we put it aboard Shuttle versus ELVs.

I think it is extremely important we not make that mistake all over again, and what I would like to hear is what is it that we can do that will assure that we push these programs forward without doing damage to your program or the overall NASA vision of what it is we are trying to accomplish.

Dr. EDELSON. Well, your concerns are very valid. I don't want to in any way indicate that they are not in our minds and we have not discussed them in our inner councils in NASA and with our advisory committees. They are very much on our minds, and we have thought a lot about them, but we have got to balance a number of things, and all things considered, I personally feel that the Agency is projecting a balanced program and that the budget reflects a good balance.

Mr. WALKER. But you are going to be in deep trouble, aren't you, if we have a $10 billion NASA budget in 1991 or 1992, and $4 billion of that is being spent for the Space Station? Your programs are going to be in deep, deep trouble at that point, and those are the figures we have before us now. We have one set of figures that came out of OMB that indicate that your budgets out through the mid-nineties are going to be about $10 billion, and in fact, you are going to be on a declining scale, and another set of figures that indicate that in that same time period we are going to be spending $4 billion a year for the Space Station.

Now, I have got to tell you that your program, based upon where the Agency is heading right now, is going to be in deep, deep trouble at that point, and I don't think we want your programs in deep, deep trouble at that point.

Now, how do we prevent that?

Dr. EDELSON. I very much appreciate your concerns, Mr. Walker. I don't believe I can give you any suggestions at this point. I think most of your questions have to be asked of Dr. Fletcher and others who are responsible for the balance.

Mr. WALKER. We asked them when they come up here, and they say they can't talk to us because the matters are under discussion at OMB, so the fact is that we are headed toward a markup at the end of this month where NASA will have basically told us that, look, we agree with you there are some problems there and so on, but we are taking a walk on discussing it with you. I will tell you, at that point, you know, whatever you end up with you better be grateful for because you won't have had any input. I personally think that is disastrous.

Thank you, Mr. Chairman.

Mr. NELSON. Without objection, we will enter Mr. Walker's opening remarks which he was not able to deliver because he was en route from Pennsylvania, and it will be a part of the record.

If you will just stay with us and if your colleagues will return to the audience, let's now have Dr. Mason and Dr. Lazerotti please join us at the table and let's proceed with their testimony.

Dr. Edelson, while they are coming up, would you answer this question? What would be the impact on the Space Science budget if the first Shuttle flight were to be delayed beyond February of 1988?

Dr. EDELSON. Our major concern would be that the Hubble Space Telescope, which is the fifth launch, would slip from that period of time, from November of 1988. So it is very important for us that they start in February and that they get those other four launches. If they don't start in February or if there is a long delay between launches, I would or my successor, I am sure, would campaign very heavily for a reorder of the manifest so that we can hold the launch of the Hubble Space Telescope at its present position of November 1988. That is a point of such enormous significance and importance to the American scientific community and to our whole program that if I had to point to one particular item, that is the one I would point to.

Mr. NELSON. Thank you.

Why don't you just stay there, Dr. Edelson. Stay with us at the table.

Dr. Mason.

## STATEMENT OF GLENN M. MASON, ASSOCIATE PROFESSOR OF PHYSICS, UNIVERSITY OF MARYLAND, REPRESENTING SPACE SCIENCE WORKING GROUP, ASSOCIATION OF AMERICAN UNIVERSITIES

Mr. MASON. Mr. Chairman, thank you for the opportunity to meet with the committee this morning. I represent the Space Science Working Group of the AAU, a consortium of universities with scientists throughout the space science community.

We want to stress this morning our belief that it is essential to the economy, welfare and security of the nation that the space science program in the United States be second to none and that the country maintain its leadership in this area. We ask that the necessary resources be provided in the fiscal year 1988 NASA budget to put us on the path to achieving this goal.

We believe that one of our national goals in rebuilding the space program should be preeminence in space science. For many years

the United States led the world in space science, and our achievements provided highly visible demonstration of the nation's scientific and technical prowess. However, in recent years the lead has eroded. The last planetary mission was launched in 1978 and was planned a decade earlier.

The Soviets meanwhile have produced a vigorous program in planetary exploration and are undertaking a mission to Mars even more ambitious than anything that we are developing in the United States. Comet Halley was visited by a probe from the Soviet Union, Europe and Japan but none from this country. In some areas of astronomy, particularly x-ray astronomy, we have been reduced to playing a supporting role.

Our Group is very pleased to note that there is a new start, the Global Geospace Science Program, in the fiscal year 1988 budget request for NASA. In this program it will put us back in a leadership position in solar-terrestrial physics, and it is a model for actions we must take to maintain our leadership in all areas of space science.

In 1987 funds were provided for instruments to be flown as part of the ISTP program, which was discussed earlier by Dr. Edelson and Dr. Shawhan. Only with the new start, the GGS program, will the United States have a clear leadership role in this international effort.

The new start, the GGS, is an important step that needs to be taken to maintain our leadership but only one of many. We believe it is essential that the following issues be addressed in the fiscal year 1988 NASA budget: first, frequent and assured access to space; second, the vitality of the university infrastructure; third, the development of advanced technologies, and fourth, the continuing pursuit of new science.

If I could turn to the question of frequent and assured access to space, we believe it is essential to a healthy space science program to have frequent access. Even when the Shuttle resumes flight, it has been perfectly clear from the testimony this morning that it cannot provide for timely launching of all the space science missions now under development, let alone any new undertakings. It is essential that the necessary resources be provided to NASA to acquire expendable launch vehicles capability.

Simply put, without ELVs, there will be no future for U.S. space science.

Frequent access to space is another cornerstone of a vigorous space science program. Large missions such as the space telescope have a vital role to play, but we wish to point out that a healthy program cannot be constructed solely from large missions where experiments in any one scientific subdiscipline come along only once in a generation. NASA must have the resources to increase the number of frequent, moderate cost missions such as those that can be launched on Delta or Scout class vehicles.

Moderate missions serve many roles. They provide the ability to explore new fields of space sciences. There are places where new techniques and ideas are proven and perfected. They provide a means for quick response and studies of new and unexpected phenomena, and they allow focused studies to take place of key prob-

lems in areas which require dedicated mission and unusual spacecraft orbits.

Finally, the moderate missions can be carried out with the frequency great enough to keep the pace of discovery at levels necessary to attract and keep the highest quality of researchers in the field. We wish to note that the pace of certain current missions could be increased if they were launched from ELVs instead of the Shuttle, and we have been very delighted to hear some of the comments you have made this morning, Mr. Chairman, on this matter.

For example, the Mars Observer, ROSAT and Ulysses could all be launched on Titans or Deltas, and we specifically recommend that the Mars Observer be planned for 1990 launch on an ELV with the funding required to do that added to the fiscal year 1988 budget. We strongly recommend that such actions be taken and, where necessary, the funds be provided for the other missions that could also be launched on ELVs.

If I could look for a moment to something particularly important to us, which is the vitality of the university infrastructure. The health of the university research programs, we believe, is essential to the health of NASA space science programs and to the health of U.S. space science and technology. Indeed, we believe these contribute significantly to the vigor and competitiveness of the economy.

As such, the health of the university research and education community should be of central concern to our national science policy. Unfortunately, over time NASA has neglected its university infrastructure when it should have been nurturing it. This was not always the case. In the 1960s, NASA had a deliberate policy to ensure healthy scientific infrastructure of research projects and personnel and facilities on the university campuses.

The revitalization of scientific infrastructure at the universities which was established 20 to 30 years ago now is long overdue. This already poor situation was exacerbated by the grounding of the Shuttle after the *Challenger* accident.

In the fiscal year 1987 and 1988 budgets, NASA has reprogrammed $20 million to $25 million to enhance the vitality of university-based research activities through the research and analysis and suborbital programs. However, at this level of funding in the current fiscal year, NASA's Office of Space Science and Applications was only able to keep some essential components in space science from dying all together.

For example, in the new budget, data analysis funding for ongoing missions in the space plasma physics area is proposed to be cut 20 percent. This action follows a plan that was devised several years ago, well before the *Challenger* accident, and which continues to be implemented in spite of the productivity of the existing spacecraft that are in orbit and the activities it supports at the universities, and despite the resolutions of the Space Science Board and other advisory committees recommending against these moves.

Of the roughly $4 million to be cut in this particular case, only about half a million may be restored from reprogrammed money.

We wish to point out that true vitality cannot be restored in any one year for $20 million to $25 million. It is only with a sustained infusion of new money over time that true vitality can be reached. The SSWG commends and supports the concept behind NASA's

plan in fiscal year 1987 and 1988 to revitalize university space science; however, we recommend that at least an additional amount, perhaps $25 million in 1988 funds, be provided for this effort in the research and analysis, data analysis and suborbital programs.

Funds for data analysis, balloons and rockets in the suborbital programs are particularly important to provide continuity to the research and education being conducted at universities.

Turning to the area of advanced technology, I would point out that concern exists throughout the country for the competitiveness of American technology in the international marketplace. There are several Federal initiatives that we know that have been proposed by the administration which contribute towards reestablishing a national competitiveness.

For example, the NSF is requesting fiscal year 1988 funds to initiate cooperative programs between universities and industry in advanced engineering. NASA is requesting funds in the civilian space technology initiative to reestablish NASA as a leader in the development of the space and aeronautics industry.

It should be noted that NASA's Office of Space Science and Applications' Advanced Technology Development, or ATD, activities also contribute to the nation's technological competitiveness. ATD activities can develop the technology important to the space science program because it promotes the development and use of state of the art technology for our science missions.

Indeed, such funds not only ensure that the technology is at the forefront, but that our missions are cost-effective. Through the use of ATD funds, difficult components of a mission that can be developed in advance of a new start reduce the likelihood of costly overruns during fabrication.

We specifically recommend that ATD funds be provided for the Comet Rendezvous and Asteroid Flyby, CRAF, which has been discussed here earlier, and also for the Advanced X-ray Facility, AXAF, and for the development of other missions and instrumentation in order to ensure that the nation's space science program is conducted with the most effective and advanced technology.

Finally, in the area of new science, which is so vital to keeping a dynamic research organization such as the Space Science community at the forefront of world research, preeminence in the U.S. space science program requires vigorous support for new and continuing scientific opportunities. Basic research is necessary and a fundamental component of the broad national and Federal goals of health, welfare, security and economic competitiveness, and as such, it should be given priority consideration in planning by national decision-makers.

The basic research programs supported by NASA are as important to our national goals as any other Federal research program.

Now, the proposed Global Geospace Science new start will ensure a leadership role in U.S. solar-terrestrial physics research. This is only one of many fields which provide challenging scientific opportunities in which the United States must compete. I want to mention a couple of other examples.

They include, first, the life sciences. The U.S. plans to establish a permanent manned presence in space; however, the adequate research on long duration human space flight does not exist in this

country. The science has been defined but has not yet been done by the scientific community. A vigorous life sciences research program aimed at overcoming the physiological and psychological barriers to long duration flight should be pursued.

We recommend that this program be augmented to maintain its current efforts and build towards future needs.

Second, the high resolution solar observatory, or HRSO, which was discussed also this morning. HRSO is planned to be a cornerstone of future studies of the sun and has been reduced in scope from an earlier version called the Solar Optical Telescope. HRSO is a facility-class instrument which will make high resolution measurements of fundamental properties of the sun. It is a candidate for Space Station instrumentation, and we believe the development of this mission should begin as soon as possible, and indeed it should begin a new start status in fiscal year 1988.

Finally, if I could mention the Explorer program. The Explorers, which have been one of the most scientifically productive and cost-effective programs in the history of space science. This program is in deep trouble. As a result of the Challenger accident, it has had to absorb more than $100 million in unanticipated costs because the funds were redirected to the modification of the COBE mission to permit a Delta launch into polar orbit in fiscal year 1989.

As a result, current planned Explorer missions have now been delayed and new missions cannot be started. The U.S. space science community is literally teeming with world class science investigations which can be carried out with moderate missions launched on Scout or Delta class rockets.

The space science community's interest and goals in these missions have been amply and repeatedly demonstrated. For example, there are the 43 Explorer proposals received by NASA last summer or the participants of the small payloads workshop at Goddard Space Flight Center last week. We believe that the Explorer program should be augmented to assure timely execution of these missions and to give a needed infusion of new science programs of a moderate size into OSSA.

Here I have described only three examples in the space and earth sciences program in need of support. Approximately $70 million in the fiscal year 1988 budget year would get these three new science initiatives off to a good start, and it should be noted that many more opportunities are waiting to be pursued.

I have outlined briefly what the Space Science Working Group believes to be the necessary components for a healthy and vigorous world class space program. The decisions that are being made on the nation's space program this year will determine the future of the endeavor for some decades. Let us move forward decisively to ensure that this nation's lead in all aspects of space, once so proudly held, does not slip away from us.

Thank you for the opportunity to present testimony. I will be happy to answer any questions.

[The prepared statement of Mr. Mason follows:]

Statement on the

FY 1988 NASA Space and Earth Sciences Program

by

GLENN M. MASON

Associate Professor of Physics and Astronomy
University of Maryland

on behalf of the

SPACE SCIENCE WORKING GROUP
Association of American Universities

and the

National Association of State Universities
and Land-Grant Colleges

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology

United States House of Representatives

March 3, 1987

## STATEMENT OF THE SPACE SCIENCE WORKING GROUP OF THE ASSOCIATION OF AMERICAN UNIVERSITIES ON THE STATE OF SPACE SCIENCE IN THE UNITED STATES

The Space Science Working Group (SSWG) of the Association of American Universities, together with scientists throughout the space science community, believe that it is essential to the economy, welfare, and security of the nation for us to retain our position of leadership in space. We call upon both the President and the Congress to commit this nation to strive toward a civilian space program that is second to none. We ask that the necessary resources be provided in the FY 1988 NASA budget to put us firmly on the path to achieving this goal.

We believe that one of our national goals in rebuilding our space program should be preeminence in space science. For many years the United States led the world in space science, and our achievements provided a highly visible demonstration of the nation's scientific and technological prowess. However, in recent years this lead has eroded, and in some areas the lead has been lost. The last American planetary mission was launched in 1978, and conceived a decade earlier. The Soviets, meanwhile, have pursued a vigorous program in planetary exploration, and are undertaking a mission to Mars even more ambitious than the important Mars Observer mission being developed in the United States. Comet Halley was visited by probes from the Soviet Union, Europe, and Japan, but none from this country. In certain areas of astronomy, particularly x-ray astronomy, we have been reduced to playing a supporting role in projects undertaken by Europe and Japan. In earth observing studies,

the United States has a slim lead, but one that risks being overtaken by other nations' programs.

The SSWG is pleased to note that there is a new start for the Global Geospace Science (GGS) program in the FY 1988 budget request for NASA. In this program, the United States will provide two spacecraft as part of the International Solar Terrestrial Program (ISTP) to study the flow of energy and material from the Sun, through the interplanetary space, and throughout the Earth's magnetosphere. Indeed, GGS is a paradigm for the actions we must take to retain our leadership position in space science. In FY 1987 funds were provided for United States instruments to be flown in supporting roles on the European and Japanese missions that will be part of ISTP. Only with the GGS program, and the spacecraft it will provide, does the United States have a leadership role in ISTP.

The new start for GGS is an important step that needs to be taken to retain our leadership, but only one of many that needs to be taken. The SSWG believes that it is essential that the following issues be addressed in the FY 1988 NASA budget: (1) Frequent and assured access to space, (2) the vitality of the university infrastructure, (3) the development of advanced technologies and (4) the continuing pursuit of new science.

FREQUENT AND ASSURED ACCESS TO SPACE

Frequent and assured access to space is essential to a healthy space science program. Even when the Shuttle resumes flight, it cannot provide for timely launching of all the space science missions under development, let alone major new planned undertakings. It is essential that the necessary resources be provided to NASA to acquire an Expendable Launch Vehicle (ELV) capability. Without ELVs there will be no future for U.S. space science.

Frequent access to space is another cornerstone of a vigorous space science program. Large missions such as the Space Telescope have a vital role to play, but a healthy program cannot be constructed solely from large missions where experiments in any one scientific subdiscipline come along only once every generation. NASA must have the resources to increase the number of frequent, moderate missions such as those which can be launched on Delta or Scout-class vehicles. Moderate missions serve many key roles: they provide the ability to explore new fields of space and earth sciences, they are the places where new techniques and ideas are proven and perfected, they provide a means for quick-response studies of new, unexpected phenomena, they allow focused studies of key problems which require dedicated missions and unusual orbits. Finally, moderate missions can be carried out frequently enough to keep the pace of discovery at levels necessary to attract and keep the highest quality researchers in the field.

We wish to note that the pace of several current major missions could be increased if they were launched from ELVs instead of the Shuttle. For example, the Mars Observer, ROSAT and Ulysses missions could be launched on Titan or Delta ELVs more quickly than on the Shuttle. The SSWG recommends that the Mars Observer be launched in 1990 on an ELV and that the funding required to do so be provided in FY 1988. We strongly recommend that such actions be taken, and, where necessary, funds be added to the FY 1988 budget to provide for these undertakings.

THE VITALITY OF THE UNIVERSITY INFRASTRUCTURE

The health of the university research enterprise is essential to the health of the NASA space programs, to the health of U.S. science and technology and indeed, to the vigor and competitiveness of our nation as a

whole. As such, the health of university research and education should be of central concern to our national science policy, and to all federal research agencies including the missions agencies. Unfortunately, over time, NASA has neglected its university infrastructure when it should have been nurturing it.

This was not always the case. In the 1960's, NASA had a deliberate policy and program to ensure a healthy scientific infrastructure of research, projects, research, personnel, and facilities. The revitalization of the scientific infrastructure at universities which was established 20-30 years ago is now long overdue. An already poor situation at universities was exacerbated by the grounding of the Shuttle after the Challenger accident.

In the FY 1987 and FY 1988 budgets, NASA has reprogramed $20-25M to enhance the vitality of university-based research activities through the Research and Analysis (R&A) and Suborbital programs. However, at this level of funding in the current fiscal year, NASA's Office of Space Science and Applications was only able to keep some essential components of space science research from dying altogether. For example, data analysis funding for ongoing missions in the Space Plasma Physics area are proposed to be cut 20% in the FY 1988 budget from FY 1987 levels. This action follows a plan devised several years ago, well before the Challenger accident, and which continues to be carried out in spite of the productivity of the existing satellite analysis activities it supports in the universities, and despite resolutions of the Space Science Board and other advisory committees. Of the roughly $4M cut in this case, approximately $0.5M may be restored from the reprogramed funds.

True vitality can not be restored in any one year for $20-25M. It is only with a sustained infusion of new money over time can true vitality be reached. The SSWG can commend and support the concept behind NASA's plan in

FY 1987 and 1988 to revitalize university space science. However, we do recommend that at least an additional $25M, in new FY 1988 funds, be provided to this effort for Research and Analysis, Data Analysis, and the Suborbital programs, particularly in areas that affect the endangered university space research effort. Funds for data analysis, and for balloons and rockets in the Suborbital program are particularly important to provide continuity to the research and education being conducted at universities.

ADVANCED TECHNOLOGY

Concern exists throughout the country for the competitiveness of American technology in the international marketplace. There are several federal initiatives which have been proposed by the Administration which will contribute towards reestablishing our national competitiveness. The National Science Foundation (NSF) is requesting FY 1988 funds to initiate cooperative programs between universities and industry in advanced engineering. NASA is requesting funds for the Civilian Space Technology Initiative to reestablish NASA as a leader in the development of space and aeronautics technology. It should be noted that NASA's Office of Space Science and Applications advanced technology development (ATD) activities also contribute to the nation's technological competitiveness. ATD activities develop the technology and instrumentation required for new space science missions. ATD is very important to the space science program because it promotes the development and use of state-of-the-art technology for science missions.

Indeed, such funds not only ensure that our technology is at the forefront, but also that our missions are cost-effective. Through the use of ATD funds, difficult components of a mission can be developed in advance of a new start, and reduce the likelihood of costly overruns during fabrication.

ATD funds should be provided for the Comet Rendezvous Asteroid Flyby (CRAF) mission and the Advanced X-Ray Facility (AXAF), and for the development of other missions and instrumentation, to insure that the nation's space science program is conducted with the most effective and advanced technology.

**NEW SCIENCE**

Preeminence in a national space science program requires vigorous support for new and continuing scientific opportunities. Basic research is a necessary and fundamental component of our broad national and federal goals of health, welfare, security and economic competitiveness. As such, it should be given priority consideration and planning by national decision makers. The basic research programs supported by NASA are as important to our national goals as any other federal research program.

The proposed FY 1988 new start for the Global Geospace Science program will ensure a leadership role for the United States in solar-terrestrial physics. But this is only one of many fields which provide challenging scientific questions and only one of many fields in which the United States must compete. I want to mention some examples of other science efforts, which should be undertaken as soon as possible and which can be undertaken in FY 1988. They include:

> **Life Sciences:** The United States plans to establish a permanent manned presence in space. However, adequate research on long-duration human space flight does not exist in this country. The science has been defined but has not yet been done by the scientific community. A vigorous life sciences research program aimed at overcoming the physiological and psychological barriers to long-duration flight should be pursued. In FY 1988, a $15M augmentation would allow this program to

maintain its current efforts and build toward our future needs.

> **The High Resolution Solar Observatory (HRSO):** HRSO, which is planned to be the cornerstone of future studies of the sun is a reduced scope and cost version of the earlier planned Solar Optical Telescope. HRSO is a facility-class instrument which will make high resolution measurements of the fundamental properties of the surface of the Sun. It is a candidate for Space Station instrumentation. Development of this mission should begin as soon as possible; $12M in FY 1988 funding would provide adequate funds for a new start status.

> **Explorers:** The Explorer program, which has been one of the most scientifically productive and cost-effective programs in the history of space science, is in deep trouble. As a result of the Challenger accident, it has had to absorb more than $100M in unanticipated costs because funds were redirected to modification of the COBE Explorer to permit a Delta launch in FY 1989. As a result, current planned missions have been delayed and new missions cannot be started. The U.S. space science community is literally teeming with world-class scientific investigations which can be carried out with moderate missions such as those launched on Scout or Delta-class rockets. The space science community's interest and goals in these missions have been amply and repeatedly demonstrated, for example, by the 43 Explorer proposals received by NASA last summer, or by the participants of the Small Payloads Workshop held last week at Goddard Space Flight Center. An additional $40M per year should be provided to the Explorer line to ensure the timely execution of these missions.

Here I have described only three examples of space and earth sciences programs in need of support; there are many more scientific opportunities waiting to be pursued.

I have briefly outlined what the Space Science Working Group believes to be the necessary components of a vigorous and world class space science program. The decisions that will be made on the nation's space program this year will determine the future of this endeavor for decades to come. Let us move forward decisively to ensure that this nation's lead in all aspects of space, once so proudly held, does not slip away from us.

Thank you for the opportunity to present this testimony. I would be pleased to answer any questions.

March 3, 1987

## BIOGRAPHICAL SKETCH

### GLENN M. MASON

Glenn M. Mason received his A.B. in Physics from Harvard College in 1965, and his Ph.D. in Physics from the University of Chicago, in 1971. He served as Research Associate and then Senior Research Associate from 1971-1977 at the Laboratory for Astrophysics and Space Research at the University of Chicago. During this period his research work involved the elemental and isotopic composition of galactic cosmic rays, and solar modulation of galactic cosmic rays. At Chicago he was co-investigator on the IMP 6, 7 and 8 satellites, and worked on the development of high resolution cosmic ray telescopes which, for example, performed the first measurements of the cosmic ray age using the $^{10}$Be abundance. Dr. Mason joined the University of Maryland Department of Physics and Astronomy in 1977, and is now Associate Professor in the department. At Maryland he has worked on the development of novel instrumentation which allows determination of the mass composition of solar and interplanetary particles in previously unexplored energy ranges. He was co-investigator on the NASA Solar Polar mission, and is currently constructing a low energy particle telescope for space shuttle flight. His research work at Maryland has concentrated on the composition of solar energetic particles, and the acceleration and transport of particles both in the solar atmosphere and in the interplanetary medium.

Publications:

"The heavy ion compositional signature in $^{3}$He-rich solar particle events," G.M. Mason, D.V. Reames, B. Klecker, D. Hovestadt, and T.T. von Rosenvinge, Astrophys. J., 303, 849, 1986.

"Temporal variations of the anomalous oxygen component, 1977-1984," G.M. Mason, B. Klecker, A.B. Galvin, D. Hovestadt, and F.M. Ipavich, Proc. 19th International Cosmic Ray Conference, (La Jolla), 5, 168, 1985.

"Temporal variations of nucleonic abundances in solar flare energetic particle events. II. Evidence for large scale shock acceleration," G.M. Mason, G. Gloeckler, and D. Hovestadt, Astrophys. J., 280, 902, 1984.

"A survey of ~1 MeV nucleon$^{-1}$ solar flare particle abundances $1 \leq Z \leq 28$ during the 1973-1977 solar minimum period," G.M. Mason, L.A. Fisk, G. Gloeckler, and D. Hovestadt, Astrophys. J., 239, 1070, 1980.

Mr. NELSON. Thank you, Dr. Mason.
Dr. Lanzerotti.

**STATEMENT OF DR. LOUIS LANZEROTTI, BELL TELEPHONE LABORATORIES, REPRESENTING SPACE AND EARTH SCIENCE ADVISORY COMMITTEE OF THE NASA ADVISORY COMMITTEE**

Mr. LANZEROTTI. Thank you very much.

I am going to deviate considerably, in fact almost entirely, from my prepared text. The text was prepared on the basis of this report which you all have a copy of, "The Crisis in Earth and Space Science." I recommend it to you highly; my prepared testimony, which I gave to Dr. Smith this morning, basically does a very quick summary of the report.

Mr. NELSON. It will be a part of the record.

Mr. LANZEROTTI. Fine.

I want to report to you very briefly some of the issues that arose in my Committee's meetings last week and our comments on the current NASA OSSA budget and program. Then, if I can have a moment or two, I want to devote them to the broader issue of the U.S. Space Science Program, which is addressed in the report, and which was brought out in various forms in the questioning this morning, particularly by Mr. Perkins and several of the other members of your subcommittee.

The SESAC, which I represent as chairman, is the Advisory Committee to OSSA. We report to the NASA Advisory Council and we represent the sciences of astronomy and astrophysics, solar-terrestrial research, planetary exploration and earth science investigations.

At our meeting we reviewed in detail the NASA budget and the OSSA budget as well as NASA planning and some of the current work going on internally in NASA on the ELVs. We were gratified that two important recommendations that we made at our June 1986 meeting, which were recommendations to NASA on the fiscal year 1988 budget (prior to its submission to the administration) are incorporated in the NASA budget request: the new start for the Global Geosciences Program, which you have heard about several times this morning, and a modest Vitality Package of short-term funding in the scientific disciplines.

Furthermore, in the looks that we had at the work going on in NASA on the expendable launch vehicles and the concept of a mixed fleet, we commend NASA for the progress being made in its mixed fleet study and fully support its newly-articulated intent to make substantial use of ELVs for compatible payloads.

We acknowledge with thanks the provision of an ELV for the cosmic background explorer, and we believe that is an important first step on the development of ELV's for scientific research. However, we recognize that the present Mixed Fleet Study, if you look at it in detail, indicates a substantial shortfall in launch capacity for the nation, not just for space science; thus, SESAC urges NASA to continue to conservatively reassess updated Shuttle and ELF flight schedules and their ultimate impact on the space and earth science program.

We fully believe that the earliest possible launch date for all missions that are launch ready would be a major objective of such a reassessment. Launching things as soon as possible, "throwing them off the Earth," certainly reduces the overall program costs and accelerates scientific return, as in the discussion that you had this morning.

Delayed missions not only cost more; their delays ripple through the program, delaying other missions and preventing timely new initiatives. Chapter 7 in our report under Management of NASA's Program, discusses this in some detail. I am not sure it would be applicable to your household budgetary program, but certainly in terms of taxpayers, I think we have some sensible things to say.

We think that it is essential that NASA seek adequate funds to begin immediate implementation of its Mixed Fleet policy.

Now, there are some other issues that we raised. I am not going to touch on all of them. If I read them all, it would sound like we are saying to throw money at all things. I am not saying that, and I want to come back to that issue in a moment or two. But there were several key points I would like to make that were not addressed in the NASA budget.

For example, in June 1986, after prioritizing the major new initiatives of the program—prioritizing the GGS as the first program—we made strong recommendations that the Advanced X-ray Astrophysics Facility and the Comet Rendezvous/Asteroid Flyby Mission be given augmentations in the budget in order to progress in a timely manner towards new starts. That is advanced funding, basically.

Such augmentations were not explicitly included in the 1988 budget, and we reiterated at our meeting, which we are transmitting to the NASA Advisory Council today and tomorrow at its meeting in progress, our earlier statement that these two programs should be supported in such a manner that they can have timely starts towards science return.

We also noted that with regard to the Vitality Package, we believe that continued support of the nation's fleet of operating scientific spacecraft and enhanced research and analysis support are important components of maintaining a vital space science program.

We reiterate and emphasize those recommendations and recommend that serious attention be given to augmenting the Vitality Package for principally university-based support in the development of the NASA fiscal year 1988 operating plan and the fiscal year 1989 budget.

We also note that we had recommended, following the cancellation of the Solar Optical Telescope, that NASA develop a lower cost alternative to SOT in order to provide scientific continuity in the nation in solar research.

NASA and the scientific community were responsive to this recommendation in their formulation of the HRSO program, but this project was not supported in the fiscal year 1988 budget request. SESAC noted in its "Crisis" Report the wastage of scientific resources produced by repeated delays, restarts, cancellations and restarts of programs, and urged continued support for this HRSO project.

There are several other recommendations in the report here. As I said, I don't want to seem to say that we just throw money at problems. However, I think the questions that arose around the subcommittee this morning, in the questioning of the NASA executives, point out very clearly the broader and more fundamental question that we face in the United States in space and earth science research.

Mr. Perkins asked questions about the El Nino, and the ozone problem; he asked about the purposes of the Hubble Space Telescope for the studying of the most distant galaxies in the universe. NASA and the nation, by such encouragement and thoughtful questioning, is at present attempting to carry out an increasingly broad space and earth science program.

The Hubble Space Telescope will not tell us what the El Nino is doing, and an earth-looking satellite to tell us about El Nino will not tell us about the galaxy. But encouraged by the American public and our elected representatives, the nation's scientists have put together well defined, thoughtful programs for carrying out a broad range of scientific endeavors by this nation.

The scope of this program and the stresses to which it is subject at the present time clearly raise the question whether NASA will actually be able to support such a wide-ranging program. For example, the run-out of the fiscal year 1988 budget, as you have seen presented here this morning projected into fiscal year 1989, requires substantial growth, of the order of $250 million, merely to continue the approved program in 1989.

SESAC, my committee, is very concerned about the implications of this in terms of the prospects for major new programs in the next year or two or three if the nation is going to study El Nino, is going to study the galaxies, is going to study the Sun. SESAC emphasized that the two most fundamental factors limiting the American preeminence in space and earth science are that the presently projected launch capabilities are inadequate to meet the needs identified in our report, and the budget is also inadequate to carry out all the activities that we are attempting.

It is not just scientists asking for more funds. Constituents are asking about El Nino. Scientific communities and even business groups want talks on galaxies. I myself have given some on the outer planets to interested citizen groups.

I think we have to make a decision at some point in the United States. I don't know whether we are capable of doing that in the United States or not, but two alternatives can be taken. First, either we provide adequate resources to carry out this comprehensive program so we can answer questions about El Nino, or we have to reduce the scope of the program and we will never be able to answer a question about El Nino. We have to decide that. It is time for a conscious decision to be made as to which course this nation is going to follow, and it should not happen by accident.

Thank you.

Mr. NELSON. Absolutely. Well, you came to a concluding point. I was going to recess the committee. We have a vote in progress and we have got about six minutes to get there. Would you like to continue on?

Dr. LANZEROTTI. I have concluded. I reached the end of my extemporaneous comments, quasi-extemporaneous comments. I feel very strongly about this issue, that we have to decide in this nation where we are going to go.

Mr. NELSON. You said it with great conviction, and we appreciate it. I am going to look forward to following this up privately in a conversation with you, Dr. Lanzerotti.

Thank you all for participating. Have a good day. The meeting is adjourned.

[Whereupon, at 12:15 p.m. the hearing was concluded.]

# 1988 NASA AUTHORIZATION

THURSDAY, MARCH 5, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 1:48 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good afternoon. Today we're going to continue our NASA budget request hearings for the fiscal year 1988, and the focus of today's hearing is going to be on the activities under NASA's Office of Space Flight, and also related activities conducted by the Air Force.

What I'm going to have is Admiral Truly testify to us; questions; I'm going to ask him to stay; I'm going to have General Rankine testify to us; questions; and then I'm going to have both of them for questions.

Now, since the *Challenger* accident, NASA and its team of contractors have been hard at work to try to straighten things out. We know the cause of the accident, and we pretty well know what has to be done to get the shuttle back to safe flight operations, as safe as possible.

So this Subcommittee is going to continue in its oversight capacity to that effect. In the recovery effort, after we get through marking up the NASA authorization bill on March 31, then we're in the month of April going to get into a series of hearings as a follow-up to the report back to us from NASA on the shuttle recovery effort.

We believe that the time is right to begin now, in light of our report on the *Challenger* accident, and in light of NASA's report back to us. We think that the time is right to readdress the basic goals and philosophy of the space shuttle program. Specifically, in this post-accident time, how should the Shuttle be viewed, and what should it be used for.

Now prior to the accident, the shuttle was viewed by NASA, and indeed, by most of the Committees in Congress that have responsibility for the space program, as the be all and do all in space transportation. Indeed, it was called the Space Transportation System [STS]. One of the things we learned from January 28, last year, was that this is no longer the case. The Shuttle is going to be a part of a mixed fleet of launch systems within NASA as well as the Defense Department.

On the other hand, it's not yet clear just how the Space Shuttle should be used in the future. The thrust of NASA's recent mixed

fleet study implies that the shuttle should be flown as much as possible, and that Expendable Launch Vehicles [ELV's] should then be used to carry payloads that cannot make it onto the shuttle manifest. Others have suggested that the Shuttle should be used only to carry payloads that require man, and that everything else ought to go on ELV's.

Well, as a nation, we need to develop a clear position on this. In a similar vein, should NASA continue, and I pose the question, and we're going to try to help answer this question, should NASA continue to develop the Filament Wound Solid Rocket Booster Case, and should it continue to certify the main engine or power setting at 109 percent, so that the shuttle can carry heavier payloads, or should all those heavier payloads be moved to ELV's? That latter option could prove to be safer, and possibly cheaper.

Now obviously these questions are not simple ones, and their answers are not intuitively obvious, and it's going to take time for NASA and this Committee to fully scrutinize these questions, and these issues, and these are heavy issues. But we've got to start the scrutiny now, so that then we can make the proper budgetary and programmatic decisions to assist you guys in NASA.

So, Admiral Truly, we're delighted to have you here, and General Rankine, and I want to turn to our ranking member for his opening comments.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. Chairman, let me join you in extending the warmest possible welcome to Admiral Truly. After a year in which NASA went through the worst period in the history of the space program, I want to publicly congratulate Admiral Truly for his outstanding leadership.

I've reviewed the testimony, and the actions that have been taken to date, and I must say that I'm quite impressed. A year ago this program was in a state of disarray. NASA was in a virtual state of siege. Critics were claiming that the problems within NASA were nearly beyond repair.

Today we can see that those critics were not just wrong, they completely misunderstood the basic strength of the NASA family. Admiral Truly has breathed new life into a demoralized program and brought it on its way back to credibility. There is a renewed sense of mission that is clearly apparent in the office of space flight.

Only a year ago, serious questions were being raised about the morale within the astronaut corps. Now we see high expectations and a willingness to get on with the work and get back to flying. These are all signs of the exceptional work that Admiral Truly has accomplished under the most trying of circumstances. And this Committee and the American people owe him more than we could ever authorize or appropriate here.

Admiral TRULY. Thank you, sir.

Mr. WALKER. Let me say also that I endorse what the Chairman has just said about the questions that we raise, and we do so in the spirit of hoping that we can help you get back to flying. We want to see you fly at the earliest possible time, just as I know you want to fly at that point.

There are some concerns that we have about the flight rate that you project for the future. We discussed those at a previous meeting, and I think we probably want to explore that further to make certain that we understand just exactly what kind of commitments we are going to be able to fulfill, using the shuttle fleet.

But for now, we certainly welcome you, and we look forward to your testimony.

Admiral TRULY. Thanks, sir.

Mr. NELSON. Welcome. Proceed, Admiral Truly.

**STATEMENT OF ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY ARNIE ALDRICH, DIRECTOR OF THE SPACE SHUTTLE PROGRAM, JOE MAHON, AND MR. WIZNEWSKI**

Admiral TRULY. Mr. Chairman, I appreciate the opportunity to be here today. With your permission, I'd like to submit my written testimony for the record, and briefly go over some oral comments. The letter in which you invited me to this hearing contained a large number of very knotty issues, many of which are things that the DOD and NASA are on a daily basis working together, and I'm pleased to be able to report these to you.

I would like to very briefly discuss space transportation policy which is the implementation of which is the job of the Office of Space Flight, to discuss the potential of expendable launch vehicles for NASA payloads, and to talk very briefly about the NASA role to be defined in the definition and development of both the Heavy Lift Launch Vehicle (HLLV), and the next generation of manned vehicle.

Since I recently testified at the full Committee on the Space Shuttle recovery, I propose not to go into detail through what I went through the other day, but I would like to start the hearing by very briefly reminding myself and everyone here of where I see us in the space shuttle recovery, and then comment on some of these other ELV and joint NASA—DOD issues.

I think that we are on a good road to recovery—to a reliable, safe flight of the Space Shuttle. The recovery, as I said the other day, is, I view it as in several broad areas. One is in organization. We have an organization in place both in the Shuttle Program, and a recent reorganization of Office of Space Flight, that I think is clean. Everybody knows who their boss is, and I know right where to go for the parts of my job. I've divided the Office of Space Flight organization into the Space Shuttle Program.

I have Arnie Aldrich here today as Director of the Shuttle Program, and I'm going to ask him, with your permission, to join me at the table. A second deputy to work expendable launch vehicles, advanced planning in upper stages, Mr. Joe Mahon, who is also here today, that I'd like to join me, and a third deputy, Mr. Wiznewski, who is Deputy for Institutions, because I feel very strongly, and NASA feels very strongly, that the institutional strength of NASA, the people at the field centers, is our strength and continues to be that, and I intend to put a personal emphasis, on that area.

I mentioned the other day specifically two subjects. One is the schedule. We are targeted for February 1988. It's extremely tight, lots of work to be done, but between the center directors and the program today, we see that the schedule fits. The real proof of the pudding on the schedule will be when we get into testing in a few months, later on this year. The next major full scale solid rocket motor test is scheduled for the 25th of this month. We continue our heavy engine test schedule. A number of orbiter changes that I mentioned the other day, and work in those, with the Cape.

The replacement orbiter is funded. We are putting those monies that we can afford, of about $16.5 million of FY 1987 money to keep some critical subcontractors alive until the appropriation is available for a full production start in August of this year. Rockwell International has also applied several millions of dollars of corporation money to this same effort. We are anxious for August 1 to come along. We'll be negotiating a contract with Rockwell later this spring, for the build of the replacement orbiter.

I would like to turn and cover some of the issues that were in your letter, because I think they are important. And the first is the potential of ELV's, Expendable Launch Vehicles for NASA payloads. We in NASA continue to provide launch service with the Scout Boosters, the Delta, the Atlas, and the Atlas Centaur. We most recently had a successful Delta flight a week or so ago, it was a GOES spacecraft, and we have another Delta on the pad with a PALAPA communications satellite on pad 17-B at Kennedy Space Center today, scheduled in a few weeks. Later on, we'll be flying the Navy's FLTSATCOM communications satellite on an Atlas Centaur.

We have been assessing, as you know, ELV options for NASA payloads. We call this a Mixed Fleet Study. It is, I believe, a sound and excellent study. It was done over a period of several months. Because of the workload, and the people that we had apply, unfortunately it was done and completed not in cycle with our budget submittal. But it is a complex, thorough evaluation of every NASA payload which would appropriately go on the shuttle, or on an ELV.

The mixed fleet study is divided into two terms, the near term 1987-1992, and that was principally to identify those ELV's that would have an impact on the FY1987 or the FY1988 budget. The next part of this study is the far term, from 1993 to the year 2000. We are just about to get heavily into that study, because that will give us the planning that we need in the future, whether the Shuttle proves to slip, or stays on schedule.

The preliminary but clear result of the mixed fleet study is that we believe that the mixed fleet for civil space is required, to augment the Space Shuttle. Whether the Space Shuttle flies at a flight rate of 13, 14, 15 or 16 flights per year. There is a clear role for a mixed fleet in the civil space program as it is in the programs that are sponsored by the DOD in the area of national security.

We do think that further assessment is required prior to a final decision on a total plan on Dr. Fletcher's part. But we think that the mixed fleet study will be a good basis for that. We have briefed your staff on the mixed fleet study, and we'd be pleased to provide

that briefing to members, if you would care to hear it. I'm proud of it.

We are taking steps now. We have provided a Delta for the COBE science vehicle launch in 1989, and that Delta is in procurement. We have looked at candidate payloads, in the Titan III and Titan IV class, through the years through 1991, and are dealing directly with the DOD on those issues. These candidate payloads would be the Tracking Data and Relay Satellites E and possibly F, and Mars Observer, as examples. As I've said, we are working in concert on a frequent and continuous basis with the DOD on all these issues.

I might mention that the joint NASA-DOD reimbursement policy has been in work in recent months since the accident, and I believe that we're close to an agreement with the Air Force on that. It includes a quid pro quo arrangement to allow the DOD to make maximum use of its funds with shuttle missions, and the same for the civil space program, NASA, on procurement of ELV's.

I'd like to mention that we fully support the President's policy of commercialization of the ELV industry, and we have taken action here also. We have basically in the area of facilities, transfer authority for companies to use NASA facilities. Much of this is in work by our Office of Commercial Programs, Mr. Gillam, although the Office of Space Flight is a major partner in these negotiations.

We have signed an agreement with General Dynamics to privatize, to provide facilities to privatize the Atlas Centaur. We're negotiating with McDonnell Douglas, so that they can use facilities to privatize the Delta. You know that McDonnell Douglas is the winning contractor in the DOD Medium Launch Vehicle. We signed an agreement in 1986 with Space Services Inc. to launch the Conestoga launch vehicle from Wallops Island, and we have provided the Martin Marietta Corporation with a draft agreement that they are presently looking at, with the potential of commercializing the Titan program, which is principally a DOD effort, but NASA is a part of that also.

As we look at U.S. space launch system requirements, in the late 1990s, in the next century, we see a shortfall of capability. And in early 1985, the President directed a joint DOD-NASA assessment, for next generation launch systems. It's called a Space Transportation Architecture Study, referred to shortly as STAS. It is to be completed the end of 1987.

We see that needs are projected to grow significantly across these years, and the study is assessing a range of scenarios, that range from a constrained mission model, to a substantial expansion containing such things as deployment of the Strategic Defense Initiative, or an aggressive civil manned exploration program, as recommended by the National Commission on Space.

In other words, the study is attempting to look at the broad range of possibilities, because its principal output will be to provide the technology that is required to achieve our goals of a highly reliable cost effective access to space for the nation. A greater launch capacity, and an operational versatility that we do not today enjoy.

It is considering both manned and unmanned vehicles. The preliminary results, and I must say preliminary, because we have not completed this joint study, indicate that there is a need for an un-

manned, partially reusable cargo vehicle in the outyears. A post-2000 space shuttle replacement for a manned vehicle, and probably a cadre of reusable orbital transfer vehicles.

I'd like to briefly mention what I see NASA's involvement in this overall effort to be. First of all, we are dealing with aspects of NASA participation on the selection, the development and the use of both the proposed Heavy Lift Launch Vehicle, and the next generation manned vehicle. NASA has a fine heritage of development expertise in large launch vehicles and their engines.

Also, the development and operation of manned spacecraft, and very importantly, the Reliability and Quality Assurance principles that deliver very high reliability. We also have available to us major test facilities for the test of booster structures, new engines, and so forth. We believe that the earliest NASA requirement for a heavy lift vehicle is 1993.

We are working closely with the DOD to complete this study: to join with them to define the Heavy Lift Launch Vehicle program, to reach an agreement on management relationships, and also to determine the proper technical balance between the use of proven, highly reliable technology that's available today and to balance that with advanced technology developments, so that we can select the most promising balance for the Nation.

Mr. Chairman, I'm pleased to be here today, and to attempt to answer your questions. With your permission, I would like to invite my two principal deputies, one for the space shuttle program, and one for expendable launch vehicles, Mr. Arnie Aldrich and Mr. Joe Mahon to the table with me, and between the three of us, we would be pleased to answer your questions.

[The prepared statement plus answers to questions asked of Admiral Truly follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

Statement of

Richard H. Truly
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

It has been almost a year since I last appeared before you to discuss the budget request for the Office of Space Flight (OSF). At that time, we were still appraising our plans and the funding requirements to once again restore the Space Shuttle to safe reliable flight. Since then, we have made significant progress in the redesign of the Solid Rocket Motor (SRM) and the safe return of the Shuttle to flight. We have targeted the first flight for February 1988. While we are planning to that date, it is a highly success-oriented schedule. If we have any concerns about safety or there are any unforeseen problems, we will not hesitate to make the necessary schedule adjustments.

The overall goals and our recovery efforts for the OSF might be summarized into six major categories. These categories include 1) safe return to flight, 2) safe and sustainable flight rate, 3) replacement orbiter, 4) redundant system capabilities, 5) right policies and procedures, and 6) research and technology advancement.

Before discussing the budget specifics, I would like to briefly summarize our accomplishments this past year.

We have accepted and taken steps to implement the changes recommended by the Presidential Commission which investigated the Challenger accident. We have identified, and scheduled the changes that must be completed before first flight in the Solid Rocket Boosters (SRB's), Space Shuttle Main Engines (SSME's), orbiter flight hardware/software and launch complex ground support equipment; have

authorized replacement orbiter production planning, and critical subsystems procurement; and have put a new management structure in place which will ensure improved program communications and management of the Space Transportation System (STS). We are reviewing options for the use of expendable launch vehicles (ELV's) for some NASA payloads. Start of production of the replacement orbiter is anticipated for August 1987 with delivery in late spring or early summer of 1991.

## FY 1988 BUDGET REQUEST

The total budget authority requested for the STS program for FY 1988 is $3,684.0 million. This authority includes $3,115.4 million for Space Flight, Control and Data Communications (SFCDC) and $568.6 million for Research and Development (R&D). Activities included in SFCDC include Shuttle Production and Operational Capability and Space Transportation Operations. The R&D appropriation for Space Transportation Capabilility Development provides funding for Spacelab, Upper Stages, Engineering and Technical Base, Payload Operations and Support Equipment, Advanced Programs, Tethered Satellite System (TSS), and the Orbital Maneuvering Vehicle (OMV).

## SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

### SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

To support these activities, the OSF is requesting $1,229.6 million in FY 1988. The objectives of this program are to provide for the continuation of modifications required to return the STS to a safe flight status, providing for a national fleet of Shuttle orbiters; main engine production and advanced development on the propulsion systems, the preparation of launch site capabilities, and the potential changes and upgrading of the STS. This line item also includes the design, test, analysis, and certification associated with the recovery actions to verify the boosters for return to flight.

The Space Shuttle, which is the key element of the STS, is the first reusable space vehicle and is configured to carry many different types of space apparatus, scientific experiments, and national security payloads. In addition to transporting materials, equipment, and spacecraft to orbit, the Shuttle offers unique capabilities that cannot be achieved with an ELV, such as the capability to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; and to perform rescue missions.

Our primary objective is to return the three-orbiter fleet to safe flight in FY 1988. The approved four-orbiter fleet includes Columbia (OV-102), (the orbiter developed and flown on five test and evaluation flights), and Discovery (OV-103) and Atlantis (OV 104), two orbiters of a lighter-weight configuration. NASA has also been directed to procure a replacement orbiter, (OV-105).

### ORBITER

A total of $403.2 million is requested for Orbiter in FY 1988. Orbiter production activities include the necessary safety modifications identified in the post 51-L review process and the development and installation of hardware, software, and procedural modifications. Work also continues on improvements to achieve greater operational capabilities, and meet system requirements.

Orbiter funds provide for the procurement of a logistics capability including an inventory of spares to support operations requirements, the continuation of previously approved systems improvement programs, necessary safety modifications identified during the post Challenger accident review process, completion of structural spares to support the production of the approved replacement orbiter, and the engineering analysis and integration support for vehicle capability buildup. Orbiter funding also provides for orbiter support activities such as the provision of the remote manipulator system (RMS) and the on-board flight software.

The orbiter logistics capability program in FY 1988 continues the lay-in of line replaceable units (LRU's), shop replaceable units, and repair parts to support the projected flight rate and reduce the use of parts from other vehicles. The funding covers flight hardware spares, ground equipment spares, scheduling, provisioning documentation, and maintenance training. In addition, funding is included to provide maintenance test equipment for intermediate, depot level, and selected vendor repair sites.

Also a new set of structural spares will be initiated in FY 1988. This effort will sustain the capability to produce another vehicle, if required in the future, in addition to providing additional spares to inventory. Structural assemblies include the wings, aft, mid and forward fuselage sections, crew module, payload bay doors, vertical tail, orbital maneuvering system pods, forward Reaction Control System (RCS) module, and body flap.

Also in FY 1988, the qualification and production of an improved auxiliary power unit (APU), inertial measuring unit (IMU), and the upgrade of the general purpose computers (GPC's) will continue. The improved APU will have longer life and higher reliability and will require substantially less ground servicing. The new GPC MOD is for lifetime, not problem solving, and is currently under development; and will add memory and increase operating speed in order to avoid the operational limitations of the current hardware; and will result in a more maintainable system. In addition, funds are included to provide necessary safety modifications such as a new carbon brake system and a crew escape system.

The orbiter funding also covers systems integration of all redevelopment analyses and hardware changes, as well as procuring orbiter support items and capability changes to the onboard flight software. Continuing development of the capabilities of the onboard primary and backup flight software is necessary in support of expanding safety requirements, system capabilities and mission unique requirements.

LAUNCH AND MISSION SUPPORT

The FY 1988 funding request totals $249.3 million. This activity supports the development of launch and mission support capabilities, principally at the Johnson Space Center (JSC) and the Kennedy Space Center (KSC). The first line of facilities at KSC was developed to support launch processing and checkout of one Shuttle vehicle through launch. A "second line" of facilities is provided in the launch site equipment budget to support processing and checkout of up to three orbiters in flow and to support the projected flight rate increases at KSC.

Second line facilities already operational include the second launch pad in the LC-39 complex, the second high bay in the orbiter processing facility (OPF), the

second mobile launch platform (MLP), and two additional high bay areas in the vehicle assembly building (VAB). An Orbiter Maintenance and Refurbishment Facility (OMRF) is now under construction and will provide a minimal maintenance and storage capability starting in the last half of 1987. The third MLP originally scheduled for completion in September 1986, is now scheduled for September 1988 consistent with our flight rate planning. This budget also contains funding required to conduct the modifications on the KSC ground support equipment (GSE) necessary to return to flight status, such as improving the external tank (ET) hydrogen vent system on the launch pad and installation of debris traps in the main propulsion system (MPS) propellant lines.

Activities are also under way to improve the capability to support the flight rate requirements at KSC. These include provision of a digital intercommunications system with associated fiber optics cabling, replacement equipment for the launch processing system, extension of the launch equipment test facility (LETF), and installation of equipment at the contingency landing sites. The MLP previously scheduled for readiness in September 1986 has been delayed until FY 1988 consistent with the adjusted flight rate requirements.

In the JSC planning, funding has been included for additional landing aids for the current, and one additional, contingency/abort landing sites. Capability improvements have been added for weather prediction and information handling to improve system monitoring, notably for anomaly tracking. A shift in priority in the ground systems replacement/refurbishment program, consistent with the Rogers Commission recommendations, has accelerated improvements in the simulation training facility including new host computers and associated interface controllers in order to improve simulation fidelity, and availability for training. Reliability, required for the longer integrated simulations and associated maintenance cost experience, will also be substantially improved with these replacements. Following recent completion of the host computer replacement in the Mission Control Center (MCC), analogous to the simulator priority just described; communication and other peripheral systems continue to be replaced/refurbished as required, on a selective basis.

To maintain training capacity in the future for the critical descent and landing phase of Shuttle flights, FY 1988 funding initiates procurement of an additional Shuttle Training Aircraft (STA). Budget planning assumes the conversion of the existing "Propfan Test Aircraft" into the additional STA. To fulfill program objectives, a kit to modify a Boeing 747 into a (second) SCA is included, thus reducing the impact of this major single point of failure. Projects that have been ongoing, but which have been rephased or otherwise restructured, include the overhaul/uprating of the SCA engines, the life extension of the T-38 aircraft, and procurement of sufficient extravehicular mobility units (EMU's) and other crew-related equipment.

PROPULSION SYSTEMS

For FY 1988, the funding request totals $552.1 million. Propulsion systems provide for the production of the SSME and the implementation of the capability to support operational requirements established for the SSME, SRB, and ET. The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations development and certification activities to improve operating margins, reliability and durability, and anomaly

resolution capability. The SRB program includes the development and qualification of the SRM'S and boosters, redesign of the hardware for reusability, and operational cost reductions. In the ET program, the objectives are to recover from STS 51-L and return to safe flight efficiently and at low cost. Systems support primarily provides for the testing of the SSME in the main propulsion test article (MPTA) configuration in addition to providing systems integration engineering support.

The total SSME ground test experience now exceeds 1,300 tests totaling approximately 270,000 seconds of test time. This experience includes 250 tests, exceeding 55,000 seconds of operation, at the full power level (FPL).

During the course of FPL testing over the past several years, it became apparent that design margins were inadequate for routine FPL flight operation and that the current SSME configuration required an unacceptable amount of maintenance at that power level. Consequently, the SSME program has been structured into three major elements under Shuttle Production and Operational Capability: (1) flight engine, (2) development engine, and (3) advanced development.

The flight engine element includes the production of new engines, retrofit of improved hardware into the fleet, and anomaly resolution activity. One additional engine is being procured to replace engines lost during ground testing during the past year.

The development engine element provides for the development, certification, and flight certification extension of improved hardware including near-term high pressure turbopump improvements such as improved blades and bearings and a redesigned hot gas manifold. The conversion of the Nation Space Technology Laboratories (NSTL) B-1 test stand to single engine test capability has been adued to the program to meet expanded ground test requirements.

The advanced development element includes the alternate turbopump program and the technology test bed. An alternate source for high pressure turbopumps was selected in August 1986. These alternate pumps will be designed for greater reliability, safety margin, and lower operational costs. The technology test bed will provide an independent means to evaluate the technical advances arising from the development program, the alternate pump effort, and the Office of Aeronautics and Space Technology (OAST) technology program.

It is currently planned to certify the improved hot gas manifold and alternate turbopumps concurrently starting in 1991. This block change will be incorporated into the fleet when the current engines reach their projected life of 30 flights starting in the early 1990's.

The SRB funding requirements support the redesign and requalification efforts necessary as a result of the STS 51-L failure. Based upon the investigation results of the failure and the actions recommended by the Presidential Commission, a complete reassessment of the certification program on all hardware and a redesign of the SRM seal configuration is under way. The failure mode and effects analysis (FMEA), critical items list (CIL), and operational procedures are being evaluated with some design changes required. Funding is also included for alternative source procurement studies for the SRM. The filament wound case (FWC) program is being slowed down as a result of the extensive changes being considered in the basic SRB program and the Air Force's decision to defer activation of the Vandenberg launch site.



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In systems support, preparations are under way for the test of three clustered engines at full power level (109%) in the main propulsion test (MPT) stand at NSTL in early 1989. This test will provide for a verification of the main propulsion system (MPS) operations at full power level using the MPS test hardware mounted in the aft end of the simulated orbiter.

The analysis of the FMEA and the CIL will be completed for the ET. Martin Marietta Corporation, the prime contractor for the ET, is also providing an independent analysis of the FMEA/CIL for the SSME and the SRB contracts. Efforts are continuing to develop processing improvements and to complete the design improvements and installation of tooling.

## CHANGES AND SYSTEMS UPGRADING

The funding request for this category in FY 1988 totals $25.0 million.

The Changes and Systems Upgrading Budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

## SPACE TRANSPORTATION OPERATIONS

The funding request for this category totals $1,885.8 in FY 1988. Operations provides the standard operational support services for the Shuttle. The Space Transportation Operations program provides for the launch of NASA missions and, on a reimbursable basis, DOD; other U.S. Government; commercial; and international missions.

The launch schedule calls for 4 flights, including the first launch, in FY 1988, 9 flights in FY 1989, and 11 flights in FY 1990. The flight rate is planned to reach a maximum 16 launches per year after the fourth orbiter becomes a part of the fleet.

The Space Transportation Operations budget provides funding in three principal areas: Flight Operations, Flight Hardware, and Launch and Landing Operations.

## FLIGHT OPERATIONS

Flight Operations, which requests $561.1 million in FY 1988, includes training, mission control, flight operations planning, payload and systems analytical integration, mission analysis, post flight anomaly resolution, sustaining engineering, and launch support services. The consolidated operations contract covering most of the flight operation functions performed at JSC has completed transition but will require renegotiation in FY 1988 due to the impacts of the STS 51-L accident. The period prior to resumption of flight is being utilized to correct deficiencies identified either by previous experience or by the accident

investigation. Training activities continue at the minimum necessary level.

Currently, the resources for Flight Operations are focused upon fixing a backlog of system discrepancies and incorporating a large number of changes to ground systems hardware, software, and procedures. Some of these are driven by the results of the ongoing process of analysis and decision-making in the wake of the STS 51-L accident. Those changes, as well as the long lead time in certain areas of flight preparation (e.g., payload analytical integration) require that work be under way now for the early Shuttle flights. Flight preparation, training of ground and flight crews (including system-wide integrated simulations), and other functions are being carried out.

The Flight Operations portion of the Shuttle Operations budget in FY 1988 continues to support that activity predominately associated with the effort at JSC to plan for and conduct STS missions from launch to landing. The functions are essentially the same as in the past: maintain and operate all the ground facilities necessary for preparation and execution and to instruct the flight and ground controller crews; maintenance and operation of operator proficiency; training and orbiter ferry aircraft; and to perform analyses and operation of the mission planning necessary to conduct and control each mission. It also includes the sustaining engineering required to integrate all flight and ground elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; and support of crew operations and training programs. Orbiter engineering manpower continues the required support of the orbiter FMEA/CIL analysis and resulting procedure and hardware modifications in addition to the sustaining engineering activities that ensure maintainability, reliability, and anomaly resolution during operations.

## FLIGHT HARDWARE

Flight hardware, which requires $923.1 million in FY 1988, includes the procurement of orbiter flight spares; SSME spares and refurbishment; SRB rate gyros; ET's and the interface hardware with the orbiter; SRM S and booster hardware and propellants; engineering and logistics support for ET/SRB/SSME hardware elements; and maintenance and operation of flight crew equipment. The consolidated operations contract covering most of the crew equipment support at JSC has been awarded and transition completed in 1986. The funding requested for the ET and SRM'S and boosters (including production of FWC's) includes long lead time materials, subassemblies, and subsystems required to sustain production.

The Flight Hardware program element in FY 1988 provides for the procurement of ET and SRB hardware and propellants; spare components for the SSME; orbiter spares including ET disconnects; sustaining engineering and logistics support for ET/SRB/SSME flight hardware elements; and maintenance and operation of flight crew equipment.

## LAUNCH AND LANDING OPERATIONS

The Launch and Landing Operations, request for $401.6 million in FY 1988 provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the ground processing facilities at KSC.

Standard service processing and preparation of payloads as they are integrated into the orbiter are also supported by this category as is procurement of liquid propellants for launch and base support. Support to landing operations at KSC and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at KSC is the primary function of the Shuttle Processing Contractor (SPC). This includes stacking of the flight hardware elements into a launch vehicle configuration, verification of the launch configuration, and operation of the launch processing system prior to lift-off. Support manpower is also provided by the SPC for booster retrieval operations, configuration control, logistics, transportation, and inventory management.

Base support to the Shuttle program is provided by the Base Operations Contractor (BOC) which completed its fourth full year of operation in January 1987. The BOC is responsible for operations support functions such as printing and graphics; calibration of instrumentation; and evaluation, test, and modification to launch support equipment.

The Payload Ground Operations Contract (PGOC), which was recently awarded to McDonnell Douglas Astronautics Corporation is the third and final consolidation for KSC operations and the major contract for the payload processing activities. PGOC will also be the primary contractor for Spacelab and Space Station payload processing at KSC, funded under their respective budgets.

## RESEARCH AND DEVELOPMENT

### SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

Principle areas of activity in Space Transportation Capability Development include efforts related to the Spacelab, the Upper Stages that place satellites in high altitude orbits, the Engineering and Technical Base support at NASA centers, Payload Operations and Support Equipment, Advanced Programs study and evaluation efforts, the development and first flight of the United States/Italian Tethered Satellite System (TSS), and the development of the Orbital Maneuvering Vehicle (OMV).

### SPACELAB

Spacelab is a major element of the STS which provides a versatile, reusable laboratory which flies to and from Earth orbit in the orbiter cargo bay. The development program has been carried out jointly by NASA and the European Space Agency (ESA). Ten European nations, including nine members of the ESA, have participated in this joint development program with NASA. The funding request is $73.5 million in FY 1988 for the Spacelab.

NASA is developing two principal versions of the Spacelab Pallet System (SPS). One will support missions requiring the igloo and pallet in a mixed cargo configuration like the Astro series; the other version will support missions that do not require use of the igloo such as the Space Technology Experiment Platform (STEP) and the TSS.

The first Spacelab reimbursable flight, Deutchland-1 (D-1), was successfully flown during the first quarter of FY 1986 and the first Goddard Space Flight Center

Spacelab Hitchhiker (HG-1) was successfully flown in the second quarter of FY 1986. The Astro-1 mission, which will be the first igloo pallet configuration of the Spacelab Pallet System (SPS), will be flown in the first quarter of 1989.

Development funds are required in FY 1988 to complete the Hitchhiker and STEP programs, complete the lay-in of both U.S. and European source spares, and to make the necessary hardware and GSE modifications and upgrades for return-to-flight recertifications as recommended by the Rogers Commission in preparation for reflight in 1989.

In addition to these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1988. Operation of the depot maintenance program for U.S.-provided and European-supplied hardware and the procurement of replenishment spares will also continue in FY 1988.

## UPPER STAGES

The STS upper stages, for which $159.7 million is requested in FY 1988, are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, and an SRM integrity program to establish an engineering data base for solid stage components.

The Inertial Upper Stage (IUS), and the commercially developed Payload Assist Modules (PAM-A, PAM-D, and PAM-DII) are currently available for use on the STS. Several other upper stages now being commercially developed, such as the Transfer Orbit Stage (TOS) and the Apogee Maneuvering Stage (AMS), will become available for use with the STS.

The Delta class PAM-D is capable of injecting up to 2,750 pound payloads into geosynchronous transfer orbit. The PAM-DII is capable of placing a 4,100 pound payload into geosynchronous transfer orbit. The Atlas/Centaur class PAM-A is capable of inserting 4,400 pound payloads into the same orbit and was system-qualified in late 1984. Forty PAM's have been launched from the Delta, Atlas, and Space Shuttle.

The Inertial Upper Stage (IUS) was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The FY 1988 budget includes funds for production, launch, flight support, and integration costs for vehicles to accommodate the TDRS C, D, E, and F missions and the Galileo, Ulysses (including a PAM-S vehicle), and Magellan planetary missions.

The TOS is a three-axis stabilized perigee stage that is being commercially developed by the Orbital Sciences Corporation (OSC) for use in the Shuttle or on Titan. It will have the capability of placing 6,000 to 13,000 pounds into geosynchronous transfer orbit. The scheduled launch availability is late 1989. Production of TOS vehicles for the Mars Observer and an International Solar-Terrestrial Physics Project (ISTP) mission is included in the FY 1988 budget.

The AMS is a three-axis stabilized liquid propellant apogee stage which has

completed preliminary design with development planned to be initiated in mid-1987. The AMS will also be commercially developed by OSC for use in the Shuttle. It will have the capability to place 5,200 pound payloads into geosynchronous transfer orbits when used alone or 6,500 pounds into geosynchronous orbit when combined with a TOS. Projected availability is late 1990.

The SRM Integrity Program objectives are to restore confidence in existing flight systems and to generate an urgently needed engineering data base for design, analysis, and testing motor components. The 19 contracts in 11 states have made excellent progress in determining root causes of persistent problems plaguing motor nozzles. Data to alleviate these problems is being generated and is being used in the Shuttle SRM redesign. Investigation of other motor components in addition to the nozzle is being considered.

## ENGINEERING AND TECHNICAL BASE

The Engineering and Technical Base (ETB) for which $139.8 is requested in FY 1988, provides the core capability for the engineering, scientific and technical support required at the Office of Space Flight (OSF) field centers for research and development activities.

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories and the White Sands Test Facility. Safety, reliability and quality assurance (SR&QA) provides a generic support capability to all OSF programs. Special effort will be dedicated to critical items list reevaluation, critical item redesigns, and hazards analysis reevaluation. The core level for the central computer complex is established as a two-shift operation. The funding for center operations base support is split in accordance with the principle that ETB will provide the core level and the benefiting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides for future studies and ground systems research and development. ETB funds at MSFC provide for multiprogram support activities, including technical labs and facilities; safety; reliability and quality assurance; computational and communications services; and, at NSTL, for facilities operations, including security.

In FY 1987 the SR&QA effort supporting OSF programs was consolidated within the ETB budget and augmented in response to the Challenger accident report.

The requested funding for the ETB in FY 1988 provides for a continuation of the FY 1987 level of support for institutional research and development facilities and services at the centers.

## PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

Payload Operations and Support Equipment provides for developing and placing into operational status the ground and flight systems necessary to support the STS payloads during prelaunch processing, on-orbit mission operations and, when appropriate, post landing processing. Included within this program area are the STS support services for NASA payloads, satellite servicing tools and techniques

development, flight demonstrations, and multimission payload support equipment. The OSF request for FY 1988 totals $83.4 million.

The Payload Operations and Support Equipment objectives are to centralize the provisioning of payload services, both unique and common, which are required beyond the basic standard services for NASA missions and to provide multimission support equipment in support of payload operations. Payload operations provides unique hardware, analyses, and launch site support services to support STS missions. Payload support equipment funds the development and acquisition of multimission reusable GSE required for a wide range of payloads. This includes test equipment required to check out payload-to-orbiter interfaces at KSC, mixed cargo hardware such as standard cable harnesses, and displays and controls related to payload bay operations.

Payload operations funding is required in FY 1988 to furnish continued payload services for currently scheduled NASA launches. Major NASA payloads receiving support during this year include Hubble Space Teiescope, Galileo, Ulysses, Magellan, Astro, and Tracking and Data Relay Satellite (TDRS). Further, efforts will continue to provide the means to maintain and repair satellites on orbit by developing a series of tools, aids, and techniques, and to demonstrate capabilities and methods of improving the efficiency of on-orbit operations. These demonstrations will provide the experience necessary for realization of the Shuttle's potential for satellite servicing missions and on-orbit assembly functions.

FY 1988 funding for multimisssion payload support equipment is required for development testing and delivery of payload common communication equipment (PCCE) to accommodate required payload data transmission and spares provisioning for Cargo Integration Test Equipment (CITE) and PCCE. Funds for fiber optic cabling and an upgraded operational intercom system in the industrial area at KSC are included in this budget to provide increased reliability and quality of data transmission among payload processing facilities. Multimission payload support equipment funding also includes orbiter/payload interface hardware for groups of payloads such as Hitchhiker, cargo bay cabling, modified aft flight deck panels, and associated display and controls.

ADVANCED PROGRAMS

The Advanced Programs effort requests $24.9 million in FY 1988. This effort is to identify potential future space initiatives and provides technical as well as programmatic data for their definition and evaluation. Activity is focused on six major areas: advanced missions, satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities. Advanced development activities are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology. Advanced planning and analysis efforts will increasingly be focused on long-range manned mission options in and beyond Earth orbit. Satellite servicing systems will continue definition and advanced development work in remote and proximity operations. Continued efforts will be made in the areas of platform systems and servicing and advanced tether applications. Advanced transportation studies are focused on study of potential future reusable orbit transfer vehicles (OTV), space-based operations of OTV's, competitive aeroassist braking techniques for OTV, Shuttle-derived launch vehicle concepts, propellant scavenging, and aft cargo

carrier concepts. Systems supporting human presence in space, as well as generic work in space structures, orbital debris management and retrieval, and artificial intelligence applications will be investigated. NASA, in conjunction with the DOD, is investigating a heavy lift launch capability and associated advanced development.

In FY 1988, major emphasis will be placed on system concept definition and key advanced developments in crew systems, geostationary Earth orbital unmanned platforms, reusable OTV's, new capability mission kits for orbital maneuvering vehicles, future tethered systems applications, satellite servicing systems near and remote from the orbiter, and second generation Shuttles. A major goal continues to be the conceptual definition of the systems architecture and space elements needed for space operations over the next twenty years.

The satellite servicing program element will continue to explore effective manned servicing concepts to extend STS operational capability for Earth orbit support of spacecraft, platforms, and constellation aggregates. The spacecraft systems program element will focus on geostationary platform capability, definition and delineation of critical mechanisms, and designs which require advanced development efforts. Detailed engineering systems analysis will be continued to determine the efficiency of future tethered platform applications. Second generation Shuttle concept studies and advanced developments will continue. In the crew systems area, new life support system concepts and advanced developments will continue focusing on post Space Station era manned missions. Also, in the crew systems area, new capabilities for EVA will be pursued. Generic studies regarding orbital debris, large structures, and system applications will be continued. Advanced manned missions beyond the Space Station will continue to be studied with expanded scope and increased depth. Studies will be conducted to identify potential lunar/Mars missions and their potential demands on the STS.

## TETHERED SATELLITE SYSTEMS

The TSS, a joint Italian/United States development effort, will provide a new reuseable capability for conducting space experiments and unique tethered applications in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission planned for 1990 are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

The development of a TSS will provide a new reusable facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. A number of significant scientific and engineering objectives can be uniquely undertaken with a TSS facility such as the observation of important atmospheric processes occurring within the lower thermosphere, new observations of crustal geomagnetic phenomena, and entirely new electrodynamic experiments interacting with the space plasma. This is being undertaken as a cooperative development program with the Italian government. Formal signing by representatives of both governments of a Memorandum of Understanding took place in March 1984.

The United States is responsible for overall program management, overall systems engineering and integration, Orbiter integration, ground and flight operations, and development of the deployment mechanism. The U.S. effort was initiated in 1984.

The Italians are responsible for the design and development of the satellite, and the European instruments being flown on the joint missions. They initiated their development efforts in 1984.

The FY 1988 funding of $7.3 million reflects a down phase of the hardware design and development consistent with a delay in the engineering verification flight from 1988 to 1990 caused by the Challenger accident.

ORBITAL MANEUVERING VEHICLE

The FY 1988 funding request for the OMV, initiated in 1986, is $80.0 million. The OMV will be a reusable, remotely operated propulsion vehicle with the capabilty to deliver, retrieve and service payloads and spacecraft deployed at a wide range of altitudes and inclinations. The selected contractor, TRW, was given authority to proceed on October 1, 1986, with contract award in December 1986. Based on current planning, the OMV capability will be available for use with the Shuttle in late 1991.

The OMV will provide a new STS reusable extension capability for conducting orbital operations with spacecraft and payloads beyond the practical operational accessibility limits of the baseline STS. By means of direct man-in-the-loop control, the space-baseable reusable OMV, operating as far as 800-1400 nautical miles from the orbiter, will provide delivery, maneuvering, and retrieval of satellite payloads to and from altitudes or inclinations beyond the existing STS capability; reboost of satellite to original operational altitudes or higher; delivery of multiple payloads to different orbital altitudes and inclinations in a single flight; and safe deorbit of satellites which have completed their useful life. It will be designed to serve the Space Station as well and to accommodate the add-on of future "mission kits" as needed to support more advanced missions such as the servicing of satellites and platforms and the retrieval of space debris which could represent an orbital hazard to all future space missions.

The funds provided in FY 1988 will be used to continue OMV hardware design and development and fabrication of test and flight hardware.

Mr. Chairman, I would like to thank you for the support we have received from you and the members of this Subcommittee. I believe that we have made progress during this last year and that with your help we can return this country to space, ensuring that we can continue America's leadership in space science, support this nation's efforts to commercialize space and re-invigorate this nation's manned space program. There is no question that we have fallen behind but, with your help, I believe that we can take the critical steps necessary to regain U.S. leadership in the exploration and use of space.

Mr. Chairman and members of the Subcommittee, this concludes my formal testimony. I would like to introduce the members of the Office of Space Flight who are seated at the table with me. To my left is Mr. Joseph Mahon, Deputy Associate Administrator, who is responsible for Flight Systems, next to him is Mr. Arnold Aldrich, Director of the National Space Transportation System, and to my right is Mr. Mack Steel, my Special Assistant for Resources Management. We will be glad to answer any questions you may have.

Questions submitted by Chairman Nelson during the March 5, 1987, hearing at which Adm. Truly testified on NASA's FY 1988 budget.

BUDGET

QUESTION 1:

What would be the budgetary impact of a six month slip in the launch date for the next shuttle?

ANSWER 1:

The answer is highly dependent on the cause of slip in launch date and when the schedule was revised. A worst case situation could require several hundred million dollars. We would have to examine the impact in the context of the effects across all affected agency programs, including the operational planning resulting from different schedules than currently planned in the FY 1988 request.

QUESTION 2:

Can you explain why the FY 1987 and FY 1988 budgets for Space Shuttle Flight Hardware and Shuttle Launch, Landing, and Flight Operations have exceeded $1.8 billion when there will be little or no actual flight activity in these years?

ANSWER 2:

The operations budgets for FY 1987 and FY 1988 have been driven by a number of considerations including the need to maintain critical skills for the flight preparation and launch crews to support the resumption of safe flight operations and similarly at the manufacturing plants to ensure quality hardware. In addition, in response to review team concerns, we have accelerated procurement of orbiter spares to minimize the need to "cannibalize" and we have added sustaining engineering manpower. As a result of the accident, a number of increased requirements are being incorporated in the processing of the vehicle and we have lost over $1.7 million of expected reimbursements due to flight delays and revised groundrules for manifesting payloads on board the Shuttle. These along with the long lead requirements for flight hardware to support the flight rate buildup in FY 1989 and FY 1990 make up the operations budget requirements.

It should be pointed out that the current FY 1987/88 budget estimates represent reductions from the pre 51-L baseline of over $850 million as indicated in the following table:

| | | FY 1987 | FY 1988 |
|---|---|---|---|
| FY 1987 | Budget (pre 51-L) | 2229 | 2356 |
| | Appropriation | 1525 | 1317 |
| | Reimbursements | 704 | 1039 |
| FY 1988 | Budget | 1847 | 1886 |
| | Appropriation | 1847 | 1886 |
| | Reimbursements | - | - |
| Total | Reduction | -382 | -470 |

QUESTION 3:

You have requested $80 million for the Orbital Maneuvering Vehicle (OMV) program. a. At this and planned future funding levels, when will the OMV be available for use? b. What is the possibility that the Space Telescope will need to be reboosted before the OMV becomes available?

ANSWER 3:

a. The OMV is planned for first launch in November 1991. The funding level requested supports this launch date.

b. The need to reboost the Hubble Space Telescope is dependent on the solar flare activity after the Hubble launch. Scientists currently predict that the solar flare impact on the Hubble Space Telescope orbit will peak sometime in 1991. Scientific data predicts the reboost requirement to occur in November 1991. However, if high solar flare activity occurs earlier in 1991 than predicted, the OMV schedule can accommodate this phenomena up to three (3) months. In addition, the HST was designed to be reboosted by the Space Shuttle.

QUESTION 4:

What is the budgetary impact on FY 1988 if you baseline a Shuttle flight rate of only 12 flights per year rather than 16?

ANSWER 4:

The normal lead time for hardware and flight planning activity is less than three years. Since the current flight planning does not exceed 12 per year until 1991 there would be little impact to the FY 1988 requirement if the planned rate were limited to 12. The rate tooling is basically in place and the rate change would not provide any significant savings. There is about $5 million in FY 1988 for long lead forgings on External Tanks that would be deferred. However, the FY 1988 projections would have to be adjusted based upon the flight rate and the affected agency programs.

## ASSEMBLY OF THE REPLACEMENT ORBITER

QUESTION 5:

It has been suggested by the Air Force that the replacement Orbiter be assembled at Vandenberg Air Force Base rather than at the Rockwell facilities in Palmdale where all of the other Orbiters were assembled.

a. What are the principal advantages and disadvantages of this idea?

ANSWER 5a:

The advantages of utilizing VAFB for the replacement orbiter assembly include:

1. Maintenance of critical shuttle skills at VAFB.
2. Better checkout equipment exists at VAFB. Option would exist to perform a complete launch flow checkout at completion of assembly.
3. The VAFB Orbiter Maintenance and Checkout Facility is a "cleaner" facility.

The disadvantages of utilizing VAFB for the replacement orbiter assembly include:

1. Some facility modifications are required.
2. Increased logistics between Downey and VAFB vs Downey and Palmdale.
3. Software development required for checkout.
4. Relocation costs.
5. The need to reactivate some portions of the VAFB activites, currently curtailed until 1991.

QUESTION 5b:

What about the loss of all of the experience of the crews at Palmdale?

ANSWER 5b:

The Palmdale crew is down to 80-100 people at this time, however, many of the workforce are still in the Palmdale vicinity, working on other programs including the B-1. It is anticipated that many will be recaptured as the B-1 production tails off. If we assemble the orbiter at VAFB many of the Palmdale area people will be offered positions at VAFB.

QUESTION 5c:

When will a decision be made on this matter?

ANSWER 5c:

This decision will be made in early summer 1987.

PRICING POLICY

QUESTION 6a:

Please describe the terms of the agreement between NASA and the Air Force regarding the price that DOD will pay for launches on the Space Shuttle and prices that NASA will pay for launches on DOD ELVs.

ANSWER 6a:

The NASA/DOD pricing policy negotiations are still in progress. Principle terms of the proposed agreement under negotiation are:

- Prices for launches will be in effect through FY 1991.
- NASA and DOD will exchange launch services and associated support services on a quid pro quo basis for DOD use of the shuttle and NASA use of ELV's.
- Quid pro quo principles should extend beyond FY 1991.
- NASA and DOD will share the resources of the Shuttle/ELV mixed fleet to provide mutual assured access to space.
- Shuttle and ELV prices will be set to recover estimated hardware costs.
- Payments between agencies will be made in January of the fiscal year prior to the fiscal year of flight (following a transition period to allow budget adjustments in FY 1988).

QUESTION 6b:

Will this agreement extend to NASA use of the Titan III?

If no, Why not? (i.e., given the high degree of commonality..at least 80 percent for component parts and almost 100 percent in launch and support personnel..between the Titan IV that the Air Force will continue to use and the Titan III that it will no longer use for DOD missions)

ANSWER 6b:

It is expected that the principles of the agreement will extend to the Titan III (e.g., quid pro quo exchange of launch services). As you correctly stated there is a high degree of commonality with the Titan IV in the production and launch facilities and skill mixes of the personnel. Our negotiations are centering on negotiating on hardware costs and the additive costs associated with the launch vehicles and the launch of those vehicles.

## SHUTTLE MANIFEST

QUESTION 7:

Suppose there were a delay of 6 months in returning the Space Shuttle to flight, how would the manifest be adjusted?

ANSWER 7:

In general the total manifest would slip by the required amount. It would, however, be adjusted to reflect National priorities. In general, those priorities are National security and high priority sciences (Tracking and Data Relay System, Hubble Space Telescope, and Planetary missions).

QUESTION 8:

What altitude can you place the Space Telescope at if you fly the mission with an engine throttle setting no greater than 100 percent?

ANSWER 8:

The ascent performance capability for the Space Shuttle is currently under review. At the present time the altitude limitation for the Space Telescope is driven by Orbital Manuvering System (OMS) capability, not SSME or ascent capability. There is currently sufficient ascent margin to allow the space telescope to reach its required altitude of 320 nautical miles even with the engine throttle setting at 100 percent.

## THEFT AT DAKAR

QUESTION 9:

Please describe the recent thefts of government property (including the theft of an entire storage building--walls and all) that have occurred at the Space Shuttle transatlantic abort landing site located in Dakar, Senegal.

What will be done to ensure that such incidents do not occur at Dakar or any other NASA site in the future?

ANSWER 9:

A summary of the recent thefts and a description of U.S. government property affected at Dakar is as follows:

| | | |
|---|---|---|
| July 1986 | TACAN Shelter | Several major items stolen. |
| December 1986 | MSBLS Azimuth Station | Entire contents removed. |
| January 1987 | MSBLS Azimuth Station | Walls of shelter removed (only remaining structure is slab, four corner studs, and roof). |
| | MSBLS Elevation Station | All electronics smashed or removed.<br>Sides of shelter ripped and cut. |
| | TACAN Station | All electronics smashed or removed.<br>Walls and roof of shelter removed. |

The NASA Inspector General is investigating these incidents to determine all the facts. NASA/KSC will assess the security situation at each overseas civil landing site and applying the knowledge gained from the Inspector General's investigation will make recommendations to NASA Headquarters to ensure protection from theft.

Further information will be furnished to the Subcommittee after completion of the Inspector General's investigation.

Mr. NELSON. Step up if you please, gentlemen. I'm going to call on the members first, and then I will wrap up the questions. Mr. Packard.

Mr. PACKARD. No questions, Mr. Chairman.

Mr. NELSON. Okay, Mr. Smith.

Mr. BOB SMITH. I have no questions at this time, Mr. Chairman.

Mr. NELSON. Mr. Buechner.

Mr. BUECHNER. I've just one, Admiral. In the earlier witnesses that we've had, there seemed to be a little misdirection as far as where NASA was going, I know where NASA is, where NASA is going, and giving us a unified message, one that those of us who support the space program, and where America is in the leading edge of technology, and all those things we like to talk about, to give us the tools to be able to share with our colleagues that there is a very defined program, and that there is organization at the top, and that you all have got your act together.

And this really isn't a question so much as just a reminder that that's very important for us, and it's important for the members of Congress, to be able to go out in the public and to make sure that they have that renewed confidence that you seem to be bringing in here, that we'd like to be able to have it and share it with the public.

Admiral TRULY. Well, I appreciate that comment, and the point of view. I think that it's been clear that NASA has been through a terribly difficult year. I do believe that we do have our act together. We have a tremendous job to do. The first part of our job is to get the Space Shuttle safely flying again, and we're putting every bit of our dollars and effort and people to that chore. But it's really the long view that's important, and I believe that the team that Dr. Fletcher has put together, both at headquarters and at the centers, is bringing us together. But, the proof will be in the pudding.

Mr. BUECHNER. Thank you. That's all the questions I have, Mr. Chairman.

Mr. NELSON. Thank you. Mr. Nagle.

Mr. NAGLE. One of the things, Admiral, that I'm concerned about I guess, is shuttle delay in terms of how that would stack up in the event that we're not able to make the February launch date, and it's significantly delayed beyond that. I guess my first question is, is that, it's still an open question in terms of whether that February date will be made or not. I mean, there's certain tests that have to be——

Admiral TRULY. It certainly is.

Mr. NAGLE. Okay. One question for you in terms of the appropriations. Are the sums that you now have, or that you're seeking, sufficient to provide for contingencies in the event you encounter problems in the course of conducting those tests?

Admiral TRULY. I've assessed the budget recently, and we have a major budget and it's a normal part of the process that's underway now, and will be coming from the field centers into headquarters in the next several weeks. My assessment today, is that even though there are a lot of threats in fiscal year 1987, in looking at where we are in expenditures and available funds, that I'm very hopeful that we can get through 1987 with the budgets that I have in the Office of Space Flight, without the application of additional monies.

I must tell you that I'm very concerned about fiscal year 1988. We have a lot of tests in progress. We have a heavy engine test program. We are in the process of assessing our manpower levels, particularly at Cape Kennedy. In the processing, we are adding requirements in interim maintenance inspections and so forth, and I believe that there's going to need to be a significant improvement in the number of engineering and quality people there for an example.

So, I am concerned about the 1988 budget more than 1987, but the OMB fully supported my budget request. When I went over and briefed them last year prior to the submittal of the budget, so I think I have the reserves, and I'm trying to manage the program as well as Arnie and I possibly can, and we're just going to have to get a little further and get a little more data from the centers in the next several months, and see FY 1988 clearly.

Mr. NAGLE. Okay. Do you have yet developed, and I assume that if you find that you're not comfortable with the funds that you have, you'll of course immediately inform the Committee?

Admiral TRULY. I certainly will.

Mr. NAGLE. Okay. Do you have—have you developed contingency plans in the event of significant shuttle delay?

Admiral TRULY. We have. When I think of shuttle delays, let me try to describe it this way. Basically the planning that needs to be done falls in one of two categories. The first is, with any slip, we will have to deal with the manifest, in other words, the scheduled payloads that are on the present manifest.

The difficult part of that is going to be the science planetary missions, because they are in launch windows that are fixed in time. Except for the planetary missions, all other payloads, both DOD, NASA, foreign, other Government agencies, are slippable with the launch schedule. There are great demands for them not to slip, particularly in some of the national security areas, but——

Mr. NAGLE. Slip means delayed?

Admiral TRULY. Delay, yes.

The problem is if we have to adjust the schedule, the same people that work those payload requirements are the very people that I have that work the mixed fleet study that I've mentioned. And so without some estimate of a schedule adjustment, I think it would be extremely counterproductive to take them off the ELV requirement, which is the other part I'm going to talk to in just a second. Because it's a major effort, for example, to assess a 3-month slip, it's different from a 6 month slip, that's different than a 4-month slip. It involves negotiations with the DOD, foreign governments, and so forth. So I have given it a great deal of thought, but no, I have not seen it prudent to use the manpower to look at specific options other than specifically within my office myself.

But the key thing to remember is going to be the planetary missions. the first one of which is Magellan, that's scheduled on the sixth or seventh flight, and as we begin to slip, we'll either have to take flights out in front of Magellan, or bump it to a later launch window, because it is fixed in time. Following that will be either Ulysses or Galileo, et cetera.

The other contingency planning that can be done, which we are doing, is looking for available expendables that could take payloads

off the shuttle, and that is specifically a part of the mixed fleet study. The first part of that identifies the first 4 or 5 payloads that I would like to get the funds for, to get ELV's, to put them on. We've recommended that to the Administrator, he is working a number of major agency problems that have stretched the dollars, and the request for ELV funds will have to be folded in to the total picture by him between other threads such as space stations costs, potential block two or second source solid rocket motor plans, et cetera.

Mr. NAGLE. So, the original question I guess was, are you developing a contingency plan in the event of shuttle delay, and just—I want to go back to where we started from. The answer is to the extent of ELV's, yes?

Admiral TRULY. Yes.

Mr. NAGLE. To the extent of the other half of that, no?

Admiral TRULY. I know what to do. I'm assisted within my office. I have chosen not to go out on an interagency study to look at various specific launch slips because it's counterproductive until we have some sort of an assessment. Furthermore, you know, I believe that there is——

Mr. NAGLE. Can I stop you right there——

Admiral TRULY. Certainly.

Mr. NAGLE. To ask a follow to that, the decision not to do the second half, other than the ELV's, is not based on a resource problem that you're having?

Admiral TRULY. No.

Mr. NAGLE. Okay, go ahead.

Admiral TRULY. Well, I take that back.

Mr. NAGLE. Okay.

Admiral TRULY. Resources with regard to people, yes. We have a tremendous workload going on in my office today. We have the space shuttle recovery going on. We have DOD price negotiations going on. We have assessments of mixed fleet in the ELV's going on. We're talking about a Heavy Lift Launch Vehicle that we very much want and will be a part of, and with a finite number of people, you just have to apply them to the right things. I believe the best way to apply the people that I have for advanced planning today, is to do the hard work we're doing on ELV's, and be prepared on the manifest, if in fact we do have to adjust the schedule.

Mr. NAGLE. Well, the Chairman is so kind in this Committee, he doesn't have a clock. So I can—but I'm trying to—I'll try to come to a conclusion quickly, but, if I understand what you're telling me is, is that you're using the resources that you have on two fronts. Number 1, the shuttle, and I don't mean only these, but predominantly the shuttle, or the ELV's, alternatives, or ELV transfers.

Admiral TRULY. That's true.

Mr. NAGLE. And if you had additional—and here—I guess here is what concerns me in this is that in putting all the emphasis on these two projects, there are other things potentially that are stacking up because the resources are to get that shuttle back up in the air. Is that fair?

Admiral TRULY. I'm not sure I understand.

Mr. NAGLE. Are there other things in addition to contingency plans that you would be doing if you had greater resources?

Admiral TRULY. No, the problem with resources that I have on this specific issue, for example, the manifest development, is a highly skilled area—In order to assess the complexities of multiple payloads and different launch systems, that's a highly skilled technique, and you could give me the resources to hire 10 people, say, so that I could do these alternate assessments, and by the time I had them trained so that they could actually do them in a professional manner, we'd probably be flying the shuttle again, so, there are a finite number of people, both in the Department of Defense and in NASA that can weigh these things together, and today I believe that we have them on the right job, which is the internal assessment.

Mr. NAGLE. No, I'm not—I don't mean even to imply that I'm questioning your judgment or allocation.

Admiral TRULY. Sure.

Mr. NAGLE. I'm simply asking whether you have enough to allocate to the various tasks? There is a crunch to the schedules.

Admiral TRULY. I wish I had more.

Mr. NAGLE. Could you tell the Committee in what ways more?

Admiral TRULY. I wish I had more people for example today, in the area of systems analysis, for new vehicles, people in flight planning and manifesting at Headquarters. We have a very good team of people at Headquarters and at the Johnson Space Center where the space shuttle manifesting is done, but it's at a level of effort that is sized for an operational flight rate, and a relatively stable manifest. And you have to appreciate that last year the painful manifest negotiations that we went through, was never done before.

When the space shuttle first started flying, there were years to sort of sneak up on that problem. Suddenly it was dumped on us with NASA science payloads, DOD payloads, and et cetera that were crying for access to space, and between the unknowns and the recovery, and the differences in capability of the various orbiters, that was a very complex process.

Mr. NAGLE. I missed the first one. I mean—I know you told me, but I didn't write it down. What was the first one you said you wish you had more of?

Admiral TRULY. Systems analysis capability, a good example is, people that can look 15, 20 years into the future, and look at new large systems, manned and unmanned, imagining technologies, and working technology studies. Just, for example, as in the Space Transportation Architecture Study.

Mr. NAGLE. Did you submit these 2, the manifest and the systems analysis capability, were those in your original budgets that you sent to OMB?

Admiral TRULY. I'd have to go back and look at that. The most crucial need that we have submitted in the people, really is absolutely today's required people in quality and engineering. In other words, quality inspectors at the centers, so forth, these needs for systems analysis people, as an example, is not a lot of people, it's mainly highly skilled, and people with experience. It just takes years to build that experience.

Mr. NAGLE. Then I'm—I promise I'm just about done. The quality inspectors, did you request those from OMB? Were those additional quality inspectors in your budget to OMB?

Admiral TRULY. We did fight for, and I went directly to Dr. Fletcher to encourage him to fight for, additional people in the 1988 budget, and we were authorized 625 people across the agency. A final allocation of those people is not complete. The OMB did support us in that.

Mr. NAGLE. Well, I know that it's awkward to come in and ask you these—maybe ask you these questions, but irrespective—forget what I asked you about submitting to OMB.

Admiral TRULY. Okay.

Mr. NAGLE. And forget what you asked Dr. Fletcher for. What sum of money, if you had it, would the system, in terms of quality inspectors, system analysis capability, and the other one that you mentioned?

Admiral TRULY. I would appreciate the opportunity to——

Mr. NAGLE. Do that in writing?

Admiral TRULY. To supply that to you later. The reason that I say that is, we've had a significant study that has gone on recently, of the processing requirements at Cape Kennedy, that are going to require people in quality and in engineering, and that study is not quite complete, but I'd be pleased to provide my estimate of those requirements.

[Information to be furnished follows:]

We have recently completed a preliminary assessment of processing requirements at the Kennedy Space Center and have concluded that additional civil service personnel may be needed. In the area of STS operations processing, 120 to 165 additional requirements were identified; in the SR&QA area 20 to 40 additional requirements were identified; and, in the area of engineering 38 additional were required. These requirements are being carefully reviewed and a determination as to how to satisfy these requirements is currently underway.

Mr. NAGLE. Thank you. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Hefley.

Mr. HEFLEY. Thank you, Mr. Chairman.

Admiral Truly, considering the number of Department of Defense classified missions that are going to be conducted in the foreseeable future, and the mission control and planning requirements for the civil missions, how did NASA react to the Department of Defense cancelling the SOPC program, the shuttle operation planning center in Colorado Springs?

Admiral TRULY. We were disappointed that the Air Force had to make that decision, and we worked and provided such data as, you know, as we could, and as they requested, as they looked at that decision. The specific impacts to us are twofold:

One is there are some jobs in the Houston area that are supported on Air Force budgets that probably will be affected, although I think you should turn the specifics of that question to the DOD. There are potentially some facilities requirements in Houston that may be affected regard to simulators and mission control center modifications. But we have not assessed them carefully enough for me to be able to give you an accurate assessment of that.

Most crucial thing that I worried about, and we have made that point clear, both within NASA and within the DOD, are the highly

trained and experienced flight operations personnel who are in Houston and an integral part of our simulation teams and our flight control teams, mostly Air Force officers on detail, and we have made a strong point so that these personnel would not be moved in such a way that we could not phase in a program to replace them with civil servants, should the Department of Defense decide to move them. They are an integral part of the Space Shuttle team.

Mr. HEFLEY. What kind of commitment have you made to the Department of Defense to pick up this slack and take care of the load that they need taken care of in this area?

Admiral TRULY. We believe that at the flight rates that we see, we will be able to control the missions from Houston and, as I said, after we negotiate and reaffirm things like security requirements for facilities and so forth with DOD and get a clearer picture of future requirements, there may be some facilities impact. But we intend to continue to support our commitments to the Department of Defense for those payloads and the missions operation that are on the manifest.

Mr. HEFLEY. Do you have any idea what the additional cost will be at this point for the security requirements, for the building of maybe an additional simulator for things that would be done at Colorado Springs if this were not the case? Whatever other expenses that might be entailed, facilities or otherwise, do you have any idea what this is going to cost NASA in addition to what NASA would have put out otherwise?

Admiral TRULY. I don't have a good feel for that. It's a quite recent decision. We have made some preliminary estimates. I intend—and we will be assessing that during this coming year, and I'd be pleased to provide that when we have the data.

Mr. HEFLEY. Mr. Chairman, I think as we look at—as we look at these budgets this year, not just the NASA budget, but also the Armed Services, Department of Defense budget, we might want to know this figure.

It's my understanding that it would cost about $20 million, $21 million to continue SOPC; that it's going to cost about $20 million in penalties to contractors to discontinue it. So it looks to me like we're going to save about $1 million there by discontinuing it. But, on the other hand, if we're going to have to put out so many million dollars down the line to retool NASA to carry this load, I'm not sure we are saving a great deal, and I'd like, Admiral, for you at this point or some point to maybe respond to this. But I'm not sure we're saving a great deal, and at the same time we are losing the advantage of having a highly secure control center for classified military missions that perhaps is not as susceptible to hurricanes and various other things that you have there in Houston.

It may be that we need a little redundancy here, and I'm not sure about that. You'd know better than I. But if we're not saving any money on this thing, I think we ought to look at that carefully.

Admiral TRULY. Yes, sir.

Mr. NELSON. Mr. Hefley, when we get General Rankine up, why don't you just ask him the question about the cancellation of SOPC? Let's just zero in, right in, on that.

All right, Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

Dick, I'd like to talk to you about a few things that you have touched on. I'd like to go, perhaps, in length on some other things that you haven't. But first, from listening to you, there's no question now that we're looking at a mixed fleet.

Admiral TRULY. I am.

Mr. VOLKMER. NASA is, or you are?

Admiral TRULY. NASA is.

Mr. VOLKMER. Right. That's what I'm saying. That's good. I think we need to come to that conclusion.

What vehicles are we looking at, besides the shuttle, in that mixed fleet? Have you made that decision yet?

Admiral TRULY. We have looked at all available ELV's and have compared—what we did in the mixed fleet study, as a part of it, was we did what we call a capture analysis. We looked at every payload on the shuttle manifest, asked the question could this payload fly on an ELV, and then we assessed every U.S. launch vehicle, Delta, Scout, Titan, Atlas, right down the line. And where there was a payload that could fly on an ELV we identified those ELVs that it would fit on, and then we did a cost analysis. For example, when we did this, incidentally, the Air Force had not yet selected a contractor for the medium launch vehicle, so we did three cost analyses. One that was for a Titan-intensive case of vehicles; one for an Atlas-intensive; and one for a Delta-intensive case.

It turns out one of the problems is that less than 25 percent of the science payloads can fly on an ELV, either because of a requirement for manned attention, manned operation, or rendevous with it later, or planned servicing, or something like that. So it's not a huge number that we could provide.

Then we worked with Dr. Edelson in OSSA and the other AAs and went to Dr. Fletcher with a recommendation what we would jointly recommend for the near-term period from now till 1992, which is the period that we would provide, if we can get the funds for, we would plan on putting on ELV's.

Mr. VOLKMER. All right. Then you're saying if you get the plans for it, you're planning to purchase some ELV's? Is that what you're telling me?

Admiral TRULY. My proposal has been that we seek the funds to purchase ELV launch support for these vehicles.

Mr. VOLKMER. All right. Have you communicated your ELV requirements to DOD? Do they know of these?

Admiral TRULY. Yes, of those vehicles that are in production in a DOD production line, we have communicated that with them. The most effort has been on a need that's very difficult for the DOD to provide, and that's the Titan 34D. The Titan 34D production line was planned to be closed down in preparation for building up for the Titan IV, and the Air Force can speak specifically to that.

We do have vehicles or spacecraft that could fly on the Titan 34D, and are quite well matched. The Tracking and Data Relay Satellite [TDRS] is one; Mars Observer science payload is another. Both of those would involve, number one, the availability of a booster, arrangements for us to pay back the Air Force to build another one, because all of theirs that are remaining are spoken for DOD payloads; and integration costs, because, for example, the

TDRS is not designed to fly aboard a Titan 34D, but we have studied that with the Air Force.

We have also worked with the Air Force on the availability of IUS upper stages. The problem is with the Titan accidents on the DOD side, and our shuttle accident, they also have a very difficult problem, but we have been communicating and continue to do so.

Mr. VOLKMER. Now those payloads that you determined could use an ELV—whichever one it was—there wouldn't be any problems you mentioned like the TDRS, you could integrate that easily with the Titan 34D, but all of the rest of them that you have identified, without going into each individual one, can be reconfigured as far as the payload fitting with the ELV?

Admiral TRULY. Yes. From the capture analysis, we know the vehicles that they can fly on, and that also includes our confidence that the vehicle can be modified with an upper stage to fly on that ELV.

Mr. VOLKMER. All right. To switch it just a little bit, Vandenberg—we talked to the gentleman also about this later—but the shuttle uses up to 1990, if we get going again next year, we're looking at SSMEs at 104 or 109——

Admiral TRULY. That's right, 104 percent.

Mr. VOLKMER. 104. Now 104 is not going to do the job with Vandenberg, is it? In most of the——

Admiral TRULY. We are causing the DOD some difficulty in performance. Incidentally, I should also say that there has been some confusion on the shuttle performance issues. I've been requested, as a matter of fact, by General Rankine in the last few weeks to reassess the shuttle performance issue and provide our assessment of that to him, and I'd be pleased to provide that information to the committee.

The bottom line is that in general the fixes that we are applying to the Space Shuttle creates additional weight which does cause us performance problems, particularly at Vandenberg. We had initially planned to use the filament wound case and at 109 percent to provide that performance at Vandenberg.

There may very well be other ways to do it, and I think the Chairman's initial comments about the filament wound case and 109 percent are very apropos, and I can give you the details of where we stand on each of those programs.

We have not backed away at this point from either of them. I personally believe that, as you know, we have been requested to provide a plan on what we would propose to do on a solid rocket motor second source or an advanced solid rocket motor. If we do propose an advanced solid rocket motor for future years, I feel very strongly that in an orderly development, we should ask to get the performance back through that development.

109 percent has been an issue that has come up after the accident, because in conjunction with the solid rocket motor failure, we have had some engine problems. We are testing today at 109 percent, as well as 104 percent, but for the immediate future that's to provide safety margin in our certification and testing program. We have no payloads on the manifest out of the Eastern Test Range data that require over 104 percent.

When the Air Force determines to phase up the funding for the West Coast shuttle launch capability, that will necessarily, I think, have to be in concert with NASA plans for making sure that we can reliably provide the performance that they will need.

Mr. VOLKMER. Basically I get out of it that we've got some problems in using Vandenberg, then, for the immediate future.

Admiral TRULY. Yes, we do. We have performance problems. We have worked them program by program with the DOD. However, we do have options to regain the performance.

Mr. VOLKMER. I understand there's improvements contemplated on the SSMEs, too, for reliability, and all these things.

Admiral TRULY. That's correct.

Mr. VOLKMER. And pumps and blades and everything else. But I'm trying to look between now, you know, when we get started next year and at least 1990 for 2 to 3 years.

Admiral TRULY. I don't think that is an issue for the payloads for the next 2 or 3 years, I don't think performance is an issue. The issue is to get back to flight with the margins and get the system back operating in a disciplined manner, so that we can deliver the flight rates that we're comfortable with from a program point of view. We're working the performance problems that we have adequately.

Mr. VOLKMER. And then we will in the future be able to use Vandenberg. You have optimism as far as that's concerned?

Admiral TRULY. I firmly believe that we will.

Mr. VOLKMER. All right. Now you did again mention during your answer there—this will be my last area I want to talk to you about, and that's on the SRBs. And could you bring us up to date where we are on first the—not the O-ring testing and qualifications, et cetera, but the competition matter?

Admiral TRULY. We are in the last month of our assessment. As you know, we funded contracts to all of the major U.S. solid rocket motor contractors to ask them to do two things. One was look at our recovery design; and secondly is look to the future as to their suggestions as to how, with a clean sheet of paper, how they believed we would look to specific designs for advanced solid rocket motor. We have that data. We have provided that study data to you. We are assessing it, and are in the last few weeks of deciding what to recommend as a program plan, and I think we are obligated to come up here on the 31st of this month, and we are going to be pushed, I don't want to ask for an extension, but I believe we are going to make it.

Mr. VOLKMER. Fine.

Then the other part is on the existing SRB with the redesign of the joint. Where are we on that, as far as time table?

Admiral TRULY. I think I will pass that one to the guy who has the real responsibility for the direct program.

Arnie, could you attempt to respond on the SRB status?

Mr. ALDRICH. We are essentially complete with the design, for the joint and for a number of other areas on the solid rocket motor and booster. Several of the areas that are part of that complete design are also a factor in the major test program that will go on during the rest of this year and further on in the next year. Because the test results are not yet in hand, in some of the areas we

are carrying additional design options or features that we are also testing, but the baseline design plan is in place as a single design with some alternatives.

We have now moved into the period where extensive testing, both from subscale motors and on partial design, full scale test rigs, and also as Admiral Truly mentioned earlier, the initial full scale motor firings. We are into that phase. We haven't had the first full scale motor firing yet, but it's scheduled this month.

We've had several test firings, if you call them firings, on the rigs to test the joint, in the field joint of the motor, where we had the problem and also the major joint between the nozzle and the first motor segment. Those tests are underway. We have had several already.

The test results we have to date are confirming the expectations of the design changes and earlier they provided additional data to confirm our analysis of the failure modes that we are attempting to correct. It's a massive test program. It is scheduled. It's tight, success oriented but I think it's also very comprehensive. At this point, we are proceeding well and the plan is marching in concert with the design expectations that we have for what we are attempting to put into place.

Mr. VOLKMER. What you are telling me, what tests you have performed already have not brought you to a conclusion to abandoning the re-design that you are presently using but to proceed with it; is that correct?

Mr. ALDRICH. They have supported proceeding. They have brought up several additional problems as we have gone—one of the things we are looking at is alternate materials for the o-ring itself and the lubricant that it works with and in the early tests, we found some additional characteristics of a grease and o-ring combination that we hadn't anticipated and that led some of the design assessments or alternatives there to become more expanded. So it hasn't changed any of the basic features of the design we have put in place, but it's adding new additional parameters to consider and be sure we are completely comprehensive in our coverage of.

Mr. VOLKMER. Mr. Chairman, if you would indulge one last question of Admiral Truly. Multiple sourcing on SRB's, is that going to continue to be delayed until we find out exactly where we are on those?

Admiral TRULY. No. That is a part of the same study that I just mentioned.

Mr. VOLKMER. All right.

Admiral TRULY. You know, what is the smartest thing to do for the future with regard to the choices between a true second source for our new re-designed motor or the possibility of going to an advanced design and you know, re-competing that. It's another one of these complex problems but the second sourcing is a part of that and we are going to recommend what we propose to do.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

Mr. NELSON. Mr. Perkins?

Mr. PERKINS. You will apologize if I am a little bit out and a little late, Mr. Chairman. I apologize to the distinguished gentle-

men testifying today. I'm not exactly sure what exactly you have gone over.

One area that interests me is the difference between the Air Force design on heavy launch vehicles and the idea of having a new heavy launch vehicle versus the NASA indication that we should use—what is it, the shuttle derived vehicle.

What type of approach—if we use the Air Force approach, what type of vehicle are we talking about, a little more specifics, and if we do use that approach, how long is it going to delay us in terms of getting the capability to do what we want?

Admiral TRULY. Let me describe to you the way that I see that problem. You know, what the Nation really needs in the long term and the thing that is the purpose of the architecture study, is a very cost effective, very, very reliable vehicle that will probably take many years to evolve.

Now, if you look down the road as to that long term goal, the question is if you have a 1993 or 1994 initial requirement, which available technology today provides the most effective way to get started down that evolutionary path.

One option obviously is to use major components of the shuttle system and it is extremely reliable, even including the tragedy of the *Challenger* accident. It's a very inviting design for an early requirement. If you think about it, you know, we have 24 times prior to the *Challenger* accident, we put a quarter million pounds in low earth orbit with this system, so obviously that is something that we jointly need to consider.

There are other options. This is something that a program office and a definition office is going to have to address. The Air Force, I understand, has formed a program office at Air Force Space Division. I am forming a heavy lift vehicle definition office at the Marshall Space Flight Center, so that we can pull together what we believe are the best parts of the NASA experience, not only from Marshall but from other centers such as Langley and Johnson, and we are just going to have to come to the table both in a management approach and a technical approach and determine how to get started down this long range line.

But the two elements that we have to have, it is clear, is a very high reliability, because we have precious payloads on both sides of the river that we cannot afford to lose. But, we also must have a very, very cost effective system.

Mr. PERKINS. I understand that it would take something like, correct me if I'm wrong, 30 launches of shuttle to put a space station into some type of usage and that with a heavy launch vehicle, it would take somewhere between 5 to 10, you know, of course, depending upon the cost in developing it, and some type of savings.

What are we talking about in terms of some timeframe that we know what direction we are going in as far as the heavy launch vehicle?

Admiral TRULY. I think that you're right. There are potential and very likely applications that I think in the end will be very cost effective and also help the shuttle, the pressure on the Shuttle, by using a heavy lift vehicle for the space station program.

There is no question in my mind that if in fact that is the way to go, we are going to have to make a decision very, very quickly to

meet that requirement and choose an approach that can integrate that development in parallel of the heavy lift vehicle and the space station development in a way that from a management point of view, we are assured we are going to get there. Now that's, you know, my view, if in fact I am right, and that is, there is a great potential for a heavy lift capability in space station, not only assembly but later in logistics.

Mr. PERKINS. How quick is very soon? I mean, when you say you are going to form a group at your organization to look at the subject. DOD is going to form a group. I'm still not getting anything specific in my head of what we are talking about. Are we talking about when we come around next year——

Admiral TRULY. The next many months, I would say. Incidentally, we have been doing a great deal of study of heavy lift launch vehicles. We have a great deal of experience, too, not only the shuttle but even the development of the Saturn vehicles for Apollo, over 300,000 pounds.

Mr. PERKINS. We don't have any Saturns now, though.

Admiral TRULY. No; we have a few engines left. We have even thought about using them. It's not practical.

Mr. PERKINS. When are we going to have a practically effective heavy launch vehicle?

Admiral TRULY. I believe that the earliest it could be delivered would be in 1993/1994 and in the case of space station, that is where we see our first requirement.

Mr. PERKINS. Okay. One other question. In terms of your tethered system which you are working with in conjunction with the Italians, what's the progress on that right now? I understand 1986, was it, there was some sort of a contract let—1984, I believe. Could you give me some kind of an update on that?

Admiral TRULY. That's one of Mr. Joe Mahon's programs. Joe?

Mr. MAHON. Mr. Perkins, the contract that you are speaking about was let with Martin Marietta in Denver, and it essentially is to provide the deployer and assemble the systems. As you know, the tethered satellite is a cooperative program between us and Italy, where Italy supplies the satellite and much of the science for the experiment, along with the United States supplying the science, we supply the deployer, they supply the satellite on it.

The contract with McDonnell Douglas is developing the deployer now and they are proceeding along. They have developed the rack which supports the satellite, which allows it to clear the orbiter and then we have the reel which is also being tested now, which allows for the tether to move out with the satellite.

One of the problems that we did have with it was some difficulty in developing the science within NASA on it. There was a large human cry to participate in it, got a larger demand than was anticipated, so it took a lot of sorting before the actual science got started. The launch is now in the 1990 timeframe, and they are proceeding well within the schedule to meet that.

Mr. PERKINS. Are there any additional experimentations or experiments planned at this time in the use of a tether in space?

Mr. MAHON. We have several organizations looking at it with us now for additional uses in the tether. The space station is quite interested in it and they are taking a look at it. We have formed an

additional tether usage working group to have different people look at it, including SDIO and NASA.

Mr. PERKINS. Does it include energy transfer experiments?

Mr. MAHON. Yes, they do. As you know, if you cut a field with an electric current, you can generate power. One of the things that we want to see is if this will really generate power by having a line flowing out and then having that current re-cut the earth's gravitational field.

Mr. PERKINS. I assume also you have some sort of gravitational experiment?

Mr. MAHON. Yes. The basic system of the tether itself depends on the different gravitation on it. The shuttle down here and the tether either above or below it.

Mr. PERKINS. In terms of producing the g-force within a Space Station?

Mr. MAHON. Yes. Additionally, it may be a great way to dispose of waste from the Space Station. A preliminary look says that maybe you could reel a tether out and then cut it and with the energy it has, it goes away from the station and you don't need additional propulsion from it.

Mr. PERKINS. I could ask for a lot, but thank you, Mr. Chairman. Thank you very much.

Mr. NELSON. Admiral Truly, we have heard some rumblings coming out of the Astronaut Office about concern about safely deploying and retrieving the tethered satellite.

Admiral TRULY. Yes, and I've asked some questions myself. I've asked over the last 3 or 4 months, Bob Crippen, to take that as an action. He's done that. I have been working with the Marshall people and as a matter of fact, about two or three days ago, reviewed a plan, a schedule of safety reviews.

The basic issue with the tether is simply that it has never been demonstrated before, that you can take an object on the end of a very long fancy string and deploy it from the Space Shuttle in such a way that you keep—the right amount of tension on the tether and to do this without losing control of the dynamics which, until it is demonstrated, is a concern.

On the other hand, I would point out that as I have reviewed this and we are not satisfied, I am not satisfied myself yet and will continue to do so. We won't fly it unless we are. But in the design of the system, the tether does not actually leave its contact with the shuttle until it is on a large boom that sticks out significantly away from the payload bay.

The thing that would concern us is if the tether got tangled in the payload bay door mechanisms or something like that, but there are some concerns. There are tremendous applications if the tether dynamics predictions are proven which is really in my view the major objective of this first tether flight. We are working it.

Mr. NELSON. You know our concern, that if it is not going to work, we want to stop spending money on it.

Admiral TRULY. Of course.

Mr. NELSON. Okay, now——

Admiral TRULY. Incidentally, I must add, in the initial reviews that we have started, I've seen nothing that says it is not going to work. I don't think it's that kind of a problem. On the other hand,

we want to get the right minds on it and make sure we have a common understanding of the orbital dynamics of the tether deployment.

Mr. NELSON. In your budget that you've submitted you have over $1.8 billion for flight operations. Do you want to explain that, when in fact there is no actual flight activity?

Admiral TRULY. Yes. I would like to talk to that Operations Budget Book because there is a part of that that can be extremely confusing.

The direct answer to your question as to why the—there's about $1.8 billion with not a lot of flight activity is simply, first of all, that the operations team that is going to have to be built up later on in 1987 and in 1988 is going to have to be in place long before the first flight.

Furthermore, as the flight rate begins to build up, that team will have to be continually augmented. As we build new flight hardware, not to support the flights that are scheduled in that year, but in coming years.

There is one other thing that is going to cause us some increased costs, and that is, the recommendations, not only of this Committee but of the Rogers Commission, have caused us to look carefully at the turnaround requirements; we've added new maintenance inspections. And that, in the end, that translates into people—quality inspection people, engineering people, and so forth.

The confusing part of this subject is really not precisely what you asked, but the fact that my budget in this area comes really from two sources: appropriated funds that the Committee and the Congress provide to us; and reimbursements. And in the situation that we found ourselves after the accident, we had planned prior to the accident, in fiscal year 1987, to receive a little over $700 million of reimbursements, which I counted on to pay my operations bills. In 1988 that number was a little over a billion dollars.

We are actually going to receive zero dollars in reimbursements in 1988.

Mr. NELSON. In 1988. You got 531 just from the Air Force in 1987.

Admiral TRULY. In 1987, at the end of that, we did get the $531 million per that debate.

So, totally even though the $1.8 billion is the required appropriated amount, the plans that we had previously for 1987 and 1988 were $2.2 billion plus and $2.3 billion including both those lines.

So, our total reduction in 1988, in our requirements, is $470 million. The $531 million that you mentioned was added to our direct appropriation.

Mr. NELSON. And it was added there because it was money that you were expecting to have, that in fact, you weren't going to get because some people were saying, well, if you're not flying, why should the Air Force be paying.

Admiral TRULY. That's correct. And had we not gotten that $531 million our problem, you know, quite obviously in this area would have been almost insurmountable, a half a billion dollars problem in the operations preparations for the launch. So that was greatly appreciated.

Mr. NELSON. Well, in your 1988 budget, how much is going to be required to support—how much dollars is going to be required to support your shuttle recovery activities?

Admiral TRULY. In our budget submittal for 1988, the way we have categorized it is into the anomaly resolution, and to answer the recommendations of the Rogers Commission.

Those two numbers that are in the budget, $153 million, and $245 million respectfully for a total of $398 million.

Mr. NELSON. Okay.

Now, how much flexibility do you have in this budget, if you have any problems, that it gives you the flexibility to try to meet——

Admiral TRULY. We planned in the, what we refer to as APA, in our—the flexibility in that budget of about 10 percent overall of my total, you know, shuttle funds. And as I said a minute ago in answer to a question from Mr. Volkmer, the availability of those numbers that I just named is what I'm not ready to say it's inadequate. But I'm not totally comfortable projecting that to FY 1988.

Mr. NELSON. All right. Now, let me make sure, I'm not sure that I understood that. You're saying that you have the flexibility with the 153 and the 245, if you have some kind of problem?

Admiral TRULY. Of the identified requirements of the time we put the budget together, about 10 percent of that represents management flexibility. And as Arnie reviews the status of the changes of the program, the additional people required, I see that as a major threat.

Mr. NELSON. Okay. Let's take one kind of problem. Suppose you had a 6 month slip in the launch date, what would you do there? The budgetary impact—we're talking about budget——

Admiral TRULY. Budget impact. In general, the schedule adjustments or slips end up being additional funds required, because you have people on the payroll, critical skills that you have to keep, you know, you desperately don't want to have to lay them off, which is a principal way of getting money. And as the flight day slips out, naturally, that's additional cost for the, you know, for the game.

If we can identify the need for schedule adjustment, if in fact we do need one, there is one thing that we can do, and Arnie and I are continuing looking at this, and that is, looking carefully at where that operations buildup occurs. If we can identify the need for schedule adjustment, we can delay that buildup, and it's principally—I would say down at the KSC, where we unfortunately had to release many, many people from, you know, from their jobs in the processing, and we're going to have to build them up. So, we'd like very much to—and plan, if we have to adjust the schedule, is to get ahead of that buildup; and that will save me, and save the Nation dollars in the budget.

Mr. NELSON. You mentioned earlier the Mixed Fleet Study. Let me give you a summary of one portion, and you tell me if this is a fairly accurate description. That in the time period, the time period you were looking at was until 1992 or 1995?

Admiral TRULY. The first phase was through 1992, and the reason for that is any ELV we provide by that year would require some funds in FY 1987 or 1988. In other words, we looked at that

first, because we saw that as the first problem that we would have to bring to you in the requesting of funds to meet that need.

Mr. NELSON. Let me just ahead and you can tell me if this is accurate. As I recall, assuming that the shuttle is flying 12 times a year, the estimated requirement for ELVs over and above the shuttle capacity, in a period of time that the best of my recollection serves me is up through 1995, was the equivalent of 50 cargo—50 payload bays worth of payloads that would have to go on ELV's in that period of time, from 1988 up until 1995.

Admiral TRULY. Mr. Chairman, may I suggest that I bring to the table Mr. Jerry Fitts who helped Darrell Branscome in doing the Mixed Fleet Study. And I think I can—and while he comes up, it might help me to answer your question directly on the numbers.

Mr. NELSON. Okay. I don't want to get too detailed. Is that generally correct what I've just stated?

Mr. FITTS. When we looked at the number of payloads, in the time period of 1988 through 1995, in total that could be moved from the shuttle to ELV's, we arrived at approximately 25 equivalent Shuttle flights worth of payloads, that were possible to move from the shuttle to ELV's. Possible in the sense that we were not constrained by the number of ELV's that were available, but rather, as Admiral Truly mentioned a little while ago, that of the payloads we looked at within the NASA area of responsibility, only 25 percent fall into the category of being able to move from the shuttle to ELV's.

Mr. NELSON. I don't know what your answer just said. Do you all have a copy of the Mixed Fleet Study?

Admiral TRULY. That's what I was looking for, Mr. Chairman. It's hard to answer your question, because I just don't happen to have the numbers.

Mr. NELSON. Okay.

I am looking at page 47 of the Mixed Fleet Study.

Admiral TRULY. Yes, sir.

Mr. NELSON. And what the chart says is just what I said. Now, let me ask you again if my interpretation is correct. Page 47 says to me that, if you fly the shuttle, and you assume that it's going to fly 12 flights a year, that over and above what the shuttle can fly in that time period, which is through 1995, that there are approximately 50 cargo bayloads of payloads, that if they're going to fly, have to go on ELV's.

Mr. FITTS. I understand how you reached that conclusion.

Mr. NELSON. Well, I reached it by 24 plus 23 is almost 50.

Mr. FITTS. Yes.

Mr. NELSON. Twenty-five plus 23 is almost 50.

Mr. FITTS. Correct. But let me take the chart that you're looking at, on the lefthand side is the bar. There's some 83 flights in that time period that would be available flying at 12 flights per year. Just above that are the ELV's, 24.5, equivalent to the Shuttle flights worth. And then you're quite right, the remaining 2.9 is a shortfall.

Mr. NELSON. Twenty-three or 22.9, not 2.9.

Mr. FITTS. And that is a shortfall against the requirements that would not be satisfied, flying the shuttle at 12 flights per year, and

at the same time moving all of those payloads that are eligible to be moved or capable of being moved from the shuttle, to ELV's.

To say now that that shortfall could be satisfied by ELV's is not what this chart is intended to show, but rather, there are no more payloads that we could move to ELV's within the NASA area of responsibility. It is a shortfall that's not being satisfied by either the shuttle or ELV's that are available.

Mr. NELSON. Well, but 23 payloads is 23 payloads sitting around that need to be in space, but they're sitting on the ground. Isn't that what shortfall means?

Mr. FITTS. 23 equivalent shuttle flights were the payloads, more than 23 payloads. But that's quite correct.

Mr. NELSON. Twenty-three cargo bays——

Mr. FITTS. That's right.

Mr. NELSON [continuing]. Of payloads that we have that need to get up into space.

Mr. FITTS. That's correct.

Mr. NELSON. Therefore, 24 and a half plus 23 is about 47 and a half, I rounded it to 50.

Mr. FITTS. Correct.

Mr. NELSON. We have the equivalent of 50 cargo bays of payloads that need to go into space.

Mr. FITTS. Correct.

Mr. NELSON. That would have to go on ELV's if your shuttle is only flying 12 times a year.

Mr. FITTS. Correct.

Mr. NELSON. Is that correct?

Mr. FITTS. That's correct.

Mr. NELSON. Okay.

Now, with that understanding then, the question is, in order to meet this kind of need, to get the payloads up, how much funding is going to be required to begin the procurement of ELV's in a significant way, to get all those 50 cargo bayloads of payloads up by 1995?

Admiral TRULY. I can't answer your question directly, because we have not completed the part of the study that goes out to that. And I realize it's confusing, but I think I can explain it.

The first thing we did was a Mixed Fleet Study that Mr. Fitts was a part of, that went out to the year 1995, to attempt to demonstrate, and I think we conclusively did, that there is a genuine requirement for a mixed fleet from a policy point of view.

The second thing we did was to look at those requirements that we really felt were reasonable and proper to attempt to get started, and that only went out to 1992. So, that's the reason—and we haven't done the rest, so I can't answer your total question. I do have the dollars that are required in FY 1987 and 1988 for the short-term recommendation.

Mr. NELSON. Up until 1992?

Admiral TRULY. Yes.

Mr. NELSON. Okay.

Admiral TRULY. Yes. And they're divided in—and they also depend—and I'll be pleased to provide this for the record, but they also depend on how the NASA/DOD quid pro quo arrangement will eventually come out, because in general the Air Force has, you

know, they can provide that for vehicles in production, but not for vehicles that are going out of production, and there's a real question on the Titan, 34D's. But I have this data for FY 1987 and 1988 without, and with a quid pro quo, for all vehicles that we need. It would require approximately $21 million in 1987 and $85 million in 1988, going all the way to, for no quid pro quo, $79 million in 1987 and $212 in 1988. And our planning——

Mr. NELSON. What do you mean, no quid pro quo?

Admiral TRULY. It's our estimate, had we not come to a pricing negotiation arrangement with the Air Force, that provides them the advantage of making best use of their funds on the shuttle, and us the disadvantage on ELV's, we would have been forced for those ELV's to have a much earlier and larger incurment of expenditures.

Mr. NELSON. Okay. So, to summarize, you are saying that, in knowing what you know that you need in the way of ELV's, between now and 1992, you need an additional $21 million in this present Fiscal Year; and you need an additional $85 million over and above what you've requested for Fiscal Year 1988 for ELV's.

Admiral TRULY. These are the numbers that we have briefed the Administrator on, assuming a quid pro quo on all vehicles. If in fact a more up front funding will be required for the Titan 34D, and I anticipate that that is in fact a legitimate requirement by the Air Force, those numbers will be somewhat larger, but as they're developed, we would be pleased to provide them to you. It's a part of the study. The decision as you know is to go ask for these funds, and it is a difficult one for the Administrator because of the other financial threats that he's also dealing with. But that has been my data provided to him.

Mr. NELSON. I thought the cost pressure on the Titan III would actually be the other way, because hasn't Martin announced that it's going to commercialize, the Titan III; and so, the cost pressures ought to be coming down the other way in order to crank up—crank up the production line, since they've made that commitment to do it.

Mr. MAHON. I think there may be a bit of confusion in the numbers on that one. The first numbers are, if we have an agreement with the Air Force, but the understanding there is that the cost in the early years is delayed until the year before launch, so it doesn't show up in 1987 and 1988.

The second number is one that has not got an agreement, and those costs show earlier in that part. Now, those are from estimates that we've gotten preliminarily from the Air Force. We have not gone to a contractor at that point in time, because the two priority missions that we're talking about require that we trade with the Air Force to get the vehicles that are in the mill, to be able to launch them and use them in the time frame when they're necessary.

Additional ones beyond that, we could equally go to the contractor and take advantage of it. The only way that we're going to be able to launch them in a time frame that we need them is by trading them with the Air Force, that is, asking them for two of their's and adding two more to their procurement.

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Mr. NELSON. And what are those two missions in those two vehicles?

Mr. MAHON. The first one would be the TDRS E, and the other one would be the Mars Observer, MO.

Mr. NELSON. So, that's the——

Mr. MAHON. Both of them—one in 1989 and the other potentially in 1990, if we make that decision.

Mr. NELSON. All right. Now, we are operating—and you tell me if this is accurate or not—we are operating on the assumption that for ELV cost for three ELV's in 1988 start, one for the Mars Observer, Titan III; Titan III for the TDRS No. 5; and a Delta 2 for the ROSAT, that the economic consequence of that in 1988 is about $100 million. Is that close enough for Government work?

Mr. MAHON. Yes, sir. I think that there might also be some preliminary funding for two additional vehicles in there, the EUVE and another scientific mission as well.

Mr. NELSON. Now, Admiral Truly, let me ask you this. This is what I don't understand, if we have to have all of this incredible number of payloads, if we're going to get them up, and they're sure not doing us any good sitting on the ground, we need to get them up. And if that is the equivalent per your chart on page 47 of approximately 50 cargo bayloads full of payload, and at least you're talking about, at least, more than two ELVs per equivalent cargo bay full.

So, looking at something in excess of 100 ELVs, pick a figure, 125 is what I picked, ELVs; if that is a reasonable figure by 1995 that we're going to need over and above what the shuttle can get up, assuming the shuttle is flying 12 times a year, then are we getting anywhere even close to it just talking about providing you just three ELV—ELV starts three in 1988?

Admiral TRULY. The request that we eventually briefed to the Administrator and recommended was not for every single payload that—first of all, it would have been impossible to find a ELV for every single payload. But we tried to do what was reasonable, and that is, which of these payloads are really the highest priority, which can be flown on the ELVs, and what is a reasonable thing for me to propose to him, to ask for in the way of funding, to go get those vehicles. And that was the proposal that you saw.

There is no question about it, in every community in this Nation that needs to get into space between the time of the Titan accidents and the *Challenger* accident and 1995, all those spacecraft are not going to get there.

Mr. NELSON. On your chart on page 47, and you do identify approximately 25 payloads that you have identified as priority items, specifically the chart says, 24.5. I'm rounding that. It's almost tax time and I automatically round the decimal to the next highest full number. So, 25 cargo payloads, all right. Then the same question applies to that. That's something in excess of 50 ELVs. So, can three starts in Fiscal Year 1988 get you to where you need to go?

Admiral TRULY. I believe the wording, high, has confused you. That does not mean high priority as determined later in our study.

We looked at the total Mixed Fleet Study of which this, is one viewgraph, we were building the case to make the point that for, at certain shuttle flight rates, and the word, "high", there means that

if we went out and really bought as many—in other words, the high side of the ELVs that were available before making a priority assessment to say, do we really want to go ask for that, that's what that word high meant. That does not mean that those 24.5 cargo bays were of a high enough priority to ask for the funding to be flown on ELVs.

Mr. NELSON. But there is some number.

Admiral TRULY. Yes.

Mr. NELSON. What is that number then under that scenario.

Admiral TRULY. I'm not sure that I understand your question. The number that—the initial start payloads that we have assessed to be high priority are those that we gave you, the ROSAT, the TDRS E, the Mars Observer and so forth.

Mr. NELSON. Here's a question, why don't you just supply this back to us. I really do understand your chart.

Admiral TRULY. All right, sir.

Mr. NELSON. But I don't think you've said what our question is, and our question is; can you identify to us on the assumption that the shuttle will fly 12 times a year, how many ELVs are you going to need between now and 1995?

Admiral TRULY. Yes. We will be able to do that when the far term part of the Mixed Fleet Study is complete.

Mr. NELSON. And when will that be?

Admiral TRULY. Jerry, can you help me? We're just starting it, as a matter of fact. We just completed the assessment of what we need in the near term; and we have just launched in to the second part of that assessment. Mr. Branscome was in contact with his counterparts down at Marshall, that he's working with, just this morning, as a matter of fact, and I haven't had an opportunity to talk to him. But I can provide our schedule for completion to you.

Mr. NELSON. All right, sir, so you are stating that information is not going to be around for several months?

Admiral TRULY. I'm told that that's a good estimate. But I can give you more detail when we can get a program plan together.

Mr. NELSON. Okay. Then what we are going to have to do is when—when the Budget Committee is trying to cut the NASA budget, and we are telling them wait a minute, we even need more money to get started on ELVs, we can't really give them a figure, then? Except the figure of what I just gave you for three ELV starts in fiscal 1988?

Admiral TRULY. That's correct.

Mr. NELSON. I cannot draw the big picture for the Budget Committee is what you're saying.

Admiral TRULY. I cannot draw it for you, because we have not completed that total assessment. Nor have I briefed to the Administrator, nor has he approved it. But it's not something that we're holding back on. Again, we're moving on as quickly as we can to get it.

Mr. NELSON. Okay. Mr. Nagle wanted for the record for the context of this discussion to be that we are still assuming under chart on page 47 that there would be a February launch date for the shuttle?

Admiral TRULY. That's correct.

Mr. NELSON. Okay. Admiral Truly, a couple of days ago Dr. Edelson testified that he has requested a Titan IV from your office. He wants to have it as a back-up launch capability for one of the planetaries, in case that there were any slip in the shuttle. Our question to you is, has there been a decision made on his request?

Admiral TRULY. That request for a—for a Titan IV was part of the recommendation that I presented to the administrator and there has not been a final decision. The availability of that vehicle would expend no dollars in 1987 and $7 million in 1988, but it was a part of my recommendation for the early—since it even required only $7 million in 1988, it was a part of my recommendation.

Mr. NELSON. Okay. So he requested it, you agreed to it, and it's passed on to your boss for a decision?

Admiral TRULY. That's correct.

Mr. NELSON. And when might that come?

Admiral TRULY. I can't predict, Mr. Chairman, and it's because I'm not aware of the context, all of the other agency threats, that Dr. Fletcher is dealing with, part of which is the dollars involved in this mixed fleet start-up.

Mr. NELSON. Okay. Let me get your feeling on this. If there were a slip in the shuttle schedule past February of 1988, that's a significant slip, what do you think about having to launch some of those planetaries on ELV's?

Admiral TRULY. My recommendation, whether there is a slip or not, is to get a Titan 34D for the Mars Observer, if we can, and there are difficulties, not in cooperation with the DOD, but in their ability to provide us a vehicle. My recommendation is that we fly that planetary on an ELV, whether there is a slip or not. I don't think that particular question would be affected by a slip.

Mr. NELSON. That it would not be what? I'm sorry.

Admiral TRULY. My recommendation wouldn't be affected——

Mr. NELSON. That's on the Mars Observer.

Admiral TRULY. On the Mars Observer. That's right.

Mr. NELSON. Right. How about the rest of them?

Admiral TRULY. I can't truthfully answer that question. The most vulnerable of the planetaries, should we suffer a slip, would be Magellan, and the next Magellan launch window, which we can look up and provide, is months down—I shouldn't guess. I don't know whether that next window would provide time to actually match up an ELV and procure it or not. It's a good question, and I will find out. I don't think a launch adjustment should necessarily impact the next planetaries down the road, which will either be Galileo or Ulysses.

Mr. NELSON. Joe, why don't you answer it? You've got the chart right now.

Mr. MAHON. The Magellan opportunities would be in 1990, in November–December timeframe. Potentially there is one in the end of the year. It would take a different trajectory. That is in conflict with Galileo or Ulysses, if you did something there, and one of those would suffer, so the next free time would be at the end of 1990, and then in an alternate period. The window for Magellan is about on a 23-month basis, but you can go with other trajectories like the Class II type trajectories with less energy.

Mr. NELSON. Can you go with a Titan III as opposed to a IV?

Mr. MAHON. On that one, yes, I believe so, yes.

Mr. NELSON. But not with Galileo and Ulysses? You either need the shuttle or a Titan IV?

Mr. MAHON. Yes, sir.

Admiral TRULY. That's correct.

Mr. NELSON. Okay. Could I ask you all to just relinquish the table, and let me bring up General Rankine for his presentation.

Excuse me. Mr. Slaughter, I didn't see you come in.

Mr. SLAUGHTER. That's all right, Mr. Chairman. I have no questions.

Mr. NELSON. Okay. And then we will get you and General Rankine together here to wrap up some things.

All right, there is a recorded vote that has just been called, so we will just use this as a time to recess, and we will vote and come right back.

Admiral TRULY. Thank you, Mr. Chairman.

[Recess.]

Mr. NELSON. All right, let's resume.

General, your written testimony will be made a part of the record. If you would proceed on an informal basis.

**STATEMENT OF BRIG. GEN. ROBERT R. RANKINE, JR., DIRECTOR OF SPACE SYSTEMS AND COMMAND, CONTROL AND COMMUNICATIONS, DEPUTY CHIEF OF STAFF, RESEARCH, DEVELOPMENT AND ACQUISITION, DEPARTMENT OF THE AIR FORCE, THE PENTAGON, WASHINGTON, DC**

General RANKINE. Thank you, Mr. Chairman. It's a pleasure to be here to participate in this hearing.

I have just about a dozen charts that I think will help to capture many of the issues that the Committee has been discussing up to this point, and I will go through those rather quickly, and then we can get into the question and answer period. But I think on the premise that a picture is worth a thousand words, in some of the cases here these charts may be helpful to illustrate a few points.

First of all, let me give you a perspective on what we see as the objectives of the space launch recovery program from a DOD perspective. (Slide 1.)

I think you have heard NASA and DOD witnesses several times prior to this discuss the fact that we would like to emerge from the accidents, the *Challenger* accident and the Titan accidents, in a better position nationally than we were before those accidents occurred. (Slide 2.)

Our policy is to maintain assured access to space, and what that means in the near term is to make sure that we have no single paths, no single nodes in our access to space, so that an incident or accident would prevent us from putting up, in DOD's case, critical national security payloads.

As we project that toward the future, we wish to maintain that posture of assured access to space, no single paths, but we would like to do it in a less expensive way, and so our future objective is to maintain that policy of assured access, but to do it at a significantly lower cost than we are able to do it today with the shuttle and the Titan 4.

Now what I'd like to do is just very briefly, a couple of charts on each, go through our plans in the near term, the mid term and the far term. (Slide 3.)

The near term is the recovery from the immediate accidents. The mid term is how do we get ELV's back into production to carry us forward to a time in the far term when we could begin introducing new expendable and manned launch vehicles. (Slide 4.)

In the near term, if I can just recap very quickly for the committee some of the happenings recently, we show the problems as perceived by the Department of Defense.

First of all, in August of 1985, we had a failure of a Titan 34D, that was Flight No. 7, and we lost a classified payload, also. The cause of the loss was the liquid propellant core vehicle, the actual pumping of liquid propellant.

We have since that time exonerated that loss, and demonstrated that with a successful launch of a Titan 34B on the 11th of February, just a month ago. That 34B, of course, did not completely have the solid rocket motors on it, so it does not completely exonerate the 34D for future use, but it does show that we have corrected the problem with the core motor.

The *Challenger*, of course, occurred in January of 1986, and that's been discussed significantly up to this point. I won't dwell on it any longer.

We then had a second Titan failure, Titan 34D, Flight No. 9, failed in April of 1986, and this time the problem was in the solid rocket motors rather than in the liquid core, and the failure occurred so close, so soon after launch, it damaged both pads. The pad repair is now complete there, and we are proceeding with nondestructive test methods which are going to clear the remaining solid rocket motors that we have at least hopefully a couple sets for use in the near future launches.

Associated with the NASA *Challenger* accident and the review of the safety of future shuttle flights, as you are well aware, the Centaur program was terminated with respect to use of the Centaur upper stage on the shuttle.

Now, of course, that can cause some difficulties for the Department of Defense in the future, because it leaves us without a capability to get payloads in the 10,000 pound class to geosynchronous orbit. That's an issue that we will have to take up in our planning, for assured access to space, dual paths to space in the future.

The impact up to this point of the Titan and the shuttle failures has been that as of this moment, the Department of Defense would have had 10 more payloads in orbit, if the accidents had not occurred. Many of the launches, of course, are on-demand launches, and so I can say with a great deal of assurance now, because we have experienced the on-orbit decays and so forth, that those launches would have, in fact, taken place. That really amounts to only 7⅓ launches, a third because we only use a third of the shuttle bay when we launch a GPS, and one of those launches would have been a GPS.

So we have missed 7⅓ launches of shuttles and Titans combined, and there are 10 payloads not now in orbit that otherwise would have flown. (Slide 5.)

The position that puts us in is depicted on this chart. You might say this is the stable of currently available vehicles for DOD launches. The capability to launch the heaviest payload with the Titan 34D and the shuttle, those two systems are now grounded.

The remaining three systems depicted there—the Atlas, the Delta and the Scout—they are available and their most recent launch in each case was a success.

You will notice that there are only six Titan 34D's left, and that is the issue that you were speaking about previously in this hearing, the issue of whether or not the DOD can make one or two of those six remaining available for NASA launches when they are already dedicated to DOD launches, and that is an issue that we are presently trying to work out between the DOD and NASA. (Slide 6.)

As we go to the mid term, the situation begins to improve, and I think you can see from this chart that it's very obvious that mid term begins in 1988. In February of 1988 we have planned for the beginning of shuttle launches again. In October of 1988, the Titan IV will begin flying. In October of 1988, Delta II, the winner of the medium launch vehicle competition, will begin flying with GPS satellites. And in April of 1988, the Titan II, the refurbished ICBM space launch vehicle, will begin flying. (Slide 7.)

The important point on this chart is this gives us the stable of launch vehicles that we believe will give us some assurance of access to space. What you see is the capability of the shuttle to launch payloads of all sizes, because it can mix smaller payloads with larger payloads, or smaller payloads together—or fly a larger payload, I should say.

We have the shuttle on the one side, complemented by three different expendable launch vehicles for large, medium and small payloads.

Mr. NELSON. And this is assuming that you are phasing out the Titan 34D?

General RANKINE. That's right, sir, in fact, the Titan 34D, the last launch of those six, is scheduled for 1989, although we anticipate that Martin-Marietta will want to commercialize the Titan III, and will continue to use the pad on the East Coast.

And in fact, speaking of the pad, in addition to the launch vehicles, we also have to concern ourselves duplication of facilities, so that we don't have a single path or a single node for access to space in that regard as well. (Slide 8.)

And so you see here that on the east coast, Kennedy and Cape Canaveral Air Force Station, we have the two shuttle pads. The Titan 4 pad, which will be associated with the initial launch capability in 1988; the Titan 34D pad that we have just discussed, which we will see its final use in 1989, but which we expect Martin-Marietta will want to make available for commercial use; and two Delta pads, Complex 17 A and B on Cape Canaveral Air Force Station, which will begin operations with the first launch in October of 1988.

On the west coast, we have the single shuttle pad which we are in the process of placing into minimum facility caretaker status in order to hold it in a position where we could bring it back into use when we determine it is appropriate to do.

There will also be two Titan IV pad—one of the new items from the President's budget and the urgent supplemental that this committee has reviewed previously.

The first pad will be operational in 1989, but we are proposing in this year's President's budget the second Titan IV pad for Vandenberg Air Force Base to become operational in 1993. This is when we see the requirements of the mission model growing to a point where an additional Titan IV pad will be needed nationally.

And finally, the Titan II pad will be operational with the first launch in April of 1988. (Slide 9.)

One word about the DOD's perspective on commercial space launch, Mr. Chairman. The DOD believes that a healthy space launch industry is important for national defense, for two reasons:

One is that it makes space more accessible because there's a broader set of vehicles out there available, if there should be a future emergency.

And secondly, it makes space more affordable, because the commercial enterprise is pumping money into technology and into a production infrastructure which can do nothing but benefit the spread of costs that the government ultimately has to pay.

So we have been encouraging industry in many ways. Of course, the Administration's policy that you have already mentioned to restrict the use of the shuttle in flying commercials was necessary, we believe, to encourage the space launch industry.

We provided an incentive in our medium launch vehicle competition for commercialization. That is, we actually looked for in our source selection the ability to provide commercial launch services in that vehicle as well and all of the competitors responded in that way.

We plan to make DOD facilities available—on a direct cost basis, and by that I mean that we are only going to charge for the incremental cost to the government of government services rendered, and we will waive the recoupment, particularly with respect to the Delta II or, for that matter, of any government-developed launch vehicle—we will waive the recoupment of development costs in any subsequent commercial sales of that vehicle. The Secretary of Defense has already made that decision.

We believe that all those things will contribute to making a U.S. commercial space launch industry feasible.

I should also mention that in Florida in December, at Patrick Air Force Base, we held a symposium inviting members of the prospective commercial launch industries, the payload companies, and the insurance companies that would be insuring those payloads and launch vehicles NASA, the Department of Transportation, the Department of Commerce, and the Air Force and the Office of Secretary of Defense all gave presentations to explain the government's involvement and the government's intentions with respect to cooperating with the creation of a national commercial space launch industry. (Slide 10.)

As we go to the far term, the far term is governed by the Space Transportation Architecture Study, which Admiral Truly already mentioned, so I won't dwell on it. (Slide 11.)

The—the major objective of the Space Transportation Architecture Study, which was participated in jointly by the Department of

Defense and NASA, was to identify an architecture for the future that would be able to reduce launch costs. Not just the vehicles involved, but the operations, the mission control, and the associated logistics, to see if we can bring down the cost of the entire infrastructure and lower the cost of space launch to the government in the future.

There are three vehicle types that come out of that architecture, the first being unmanned cargo vehicle, which we now call the heavy lift launch vehicle. We had perceived that to be something on the order of 150,000 pounds, and to be available in the late 1990's. But as we looked at that, particularly in the Air Force, we felt that there were elements of that system that could be made available earlier.

For example, as I have depicted on the chart here, elements of an objective system as shown in the center could—like the core vehicle, be available earlier, and might offer an opportunity to transition into lower costs and new systems and heavier lift capability sooner than waiting for the entire objective system, and I will get back to that in a moment.

From the standpoint of a manned vehicle, here the objective is to have a system that would be available to replace the shuttle, as the shuttle begins to reach the end of its useful life after the year 2000.

Since we wouldn't need to make a decision to begin full scale development for that replacement vehicle until the mid-1990's, our primary objective would be technology between now and the early 1990's, to make available a range of options for the nature of that vehicle. And so we see that the National Aerospace Plane Program, for example, provides the technical basis for an air breathing stage, and programs that are being conducted by NASA and by the Air Force will provide for rocket technology, if we decide to go the rocket route. It's also possible to go, as the British HOTAL has gone, to a hybrid, where we might use an air-breathing lower stage and a rocket upper stage.

But all those are options, and what our main objective is is to provide the technology that will permit pursuit of any of those, the evaluation of all of those and the pursuit of the right one for the nation in the mid-1990s.

Finally, we have the reusable orbital transfer vehicle, which we believe would reduce the costs of upper stages, and the overall transportation cost, by making it unnecessary to carry the upper stage with you on each transit of the cargo vehicle to lower earth orbit. (Slide 12.)

To give you a perspective on the timing of these options, this chart shows those same three, the bottom three bars. The more or less mottled area on the left-hand side of each bar is intended to indicate a period of technology which would then notionally lead to full scale development and then initial launch capability at the end. And so that's what we have shown in each case.

I want to point out that up through the year 1990 and into the early 1990's that we are talking about technology, and that's what Admiral Truly pointed out, that the Space Transportation Architecture Study was focusing on the technology that we need to invest in today to make options available for heavy lift launch ve-

hicle for manned vehicles and for orbital transfer vehicles in the future.

Now one thing I have added at the top of the chart is a new upper stage, which would be in the 10,000 pound class, but would be safe to fly on the shuttle. As I mentioned earlier in my remarks, the Centaur not being able to fly on the shuttle prohibits us from putting payloads in the 10,000 pound class into equitorial orbit, using the shuttle, and consistent with our need to have assured access to space, we believe we need to correct that problem, and we have begun conceptual designs in pursuit of technology for a storable liquid upper stage that could safely fly in the shuttle and, combined with shuttle performance, could give us the capability to take 10,000 pounds from lower earth orbit from the shuttle up to geosynchronous orbit.

Now you notice at the top of the chart it says without the supplemental, and what you see in this chart had been discussed by the Department of Defense and NASA up through about the December time period, and was really the basis for our thinking at that time. (Slide 13.)

However, one thing we also agreed to was that if the Heavy Lift Launch Vehicle needs to be accelerated because of SDI needs or NASA needs beyond what is shown there, that there would have to be additional funding applied to the budget. And therein lies the rationale for the DOD's supplemental for fiscal year 1987, and you will notice that what we have depict that that has done is to increase the amount of money that's being spent on technology in the early years so that presumably we could get to technical maturity sooner. It's also pulled back the beginning of full scale development so that there's a bit of concurrency between the completion of the technology work and the beginning of the full scale development work.

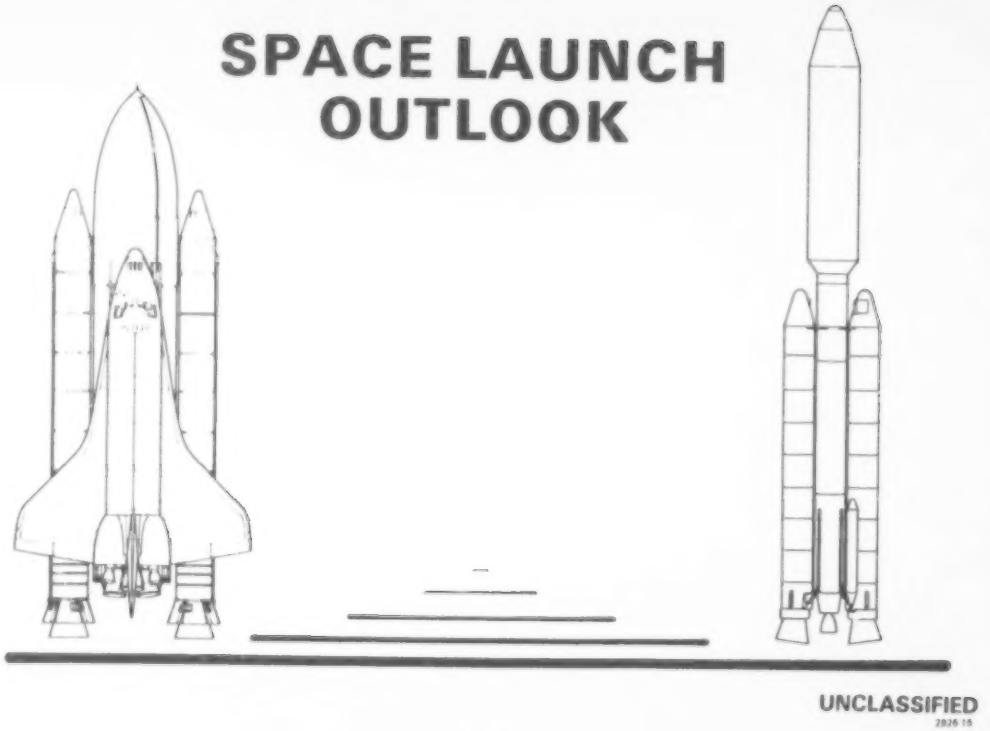
That's what we believe is possible to do with the additional resources, and we think that that might make an objective Heavy Lift Launch Vehicle that could significantly reduce the cost of putting payload into orbit available in the mid-1990's, also along with that, elements of the new system could be available as early as 1993 or 1994. That happens to be the same timeframe that you have heard expressed by NASA as a need date in support of the space station.

And so that's been the basis here recently for discussions between NASA and the DOD, to see if there isn't a way to accommodate NASA's needs and the DOD's needs with the same program. And we have recently invited NASA to join us in program research and development announcements that would go out to industry, to see if there is a single system that would meet our near term needs and our far term cost reduction needs, and put both of those would be on the same path. (Slide 14.)

In conclusion, I believe that the Air Force, NASA and Strategic Defense Initiative Organization, who are jointly investing in space launch technology and space launch vehicles, are working cooperatively to implement what is a balanced program for assured access to space in the future.

That concludes my remarks, Mr. Chairman. I'd be glad to answer any questions.

[Slides 1–14 of General Rankine's oral presentation plus his prepared statement follow:]




SLIDE 1

# NATIONAL SECURITY OBJECTIVE AND STRATEGY

- OBJECTIVE
  - —ENSURE A MORE CAPABLE LAUNCH POSTURE THAN BEFORE CHALLENGER FAILURE
- STRATEGY
  - —NEAR-TERM: NO SINGLE NODES OR PATHS
    - LAUNCH VEHICLES
    - LAUNCH FACILITIES
  - —FAR-TERM: THE ABOVE PLUS SIGNIFICANTLY LOWER COST





SLIDE 2

# NEAR TERM





SLIDE 3

UNCLASSIFIED

# RECAP OF RECENT LAUNCH PROBLEMS

- TITAN 34D-7 FAILURE—AUGUST 1985
  - —CAUSE: STAGE 1 PROPELLANT FEED SYSTEM FAILURE
  - —LIQUID MOTOR PROBLEMS SOLVED: 11 FEB 87 WITH TITAN III/34B LAUNCH
- CHALLENGER ACCIDENT—JANUARY 1986
  - —CAUSE: SOLID ROCKET BOOSTER JOINT FAILURE
  - —NASA PLANS TO RESUME LAUNCHES FEB 88
- TITAN 34D-9—APRIL 1986
  - —CAUSE: SOLID ROCKET MOTOR CASE INSULATION DEBOND
  - —PAD REPAIR COMPLETE
  - —NONDESTRUCTIVE TESTS DEVELOPED: RESUME LAUNCHES IN 1987
- SHUTTLE CENTAUR TERMINATION
  - —CAUSE: SHUTTLE SAFETY CONCERNS
  - —AIR FORCE PURSUING DUAL-COMPATIBLE HIGH-ENERGY UPPER STAGE
- IMPACT: 10 DOD PAYLOADS—7 1/3 MISSED LAUNCHES

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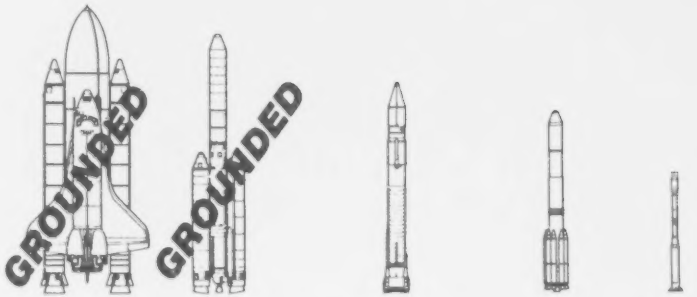
2654 B



SLIDE 4

UNCLASSIFIED

# CURRENT LAUNCH VEHICLE ASSETS




| LAUNCH VEHICLE: | | SPACE SHUTTLE | TITAN 34D | ATLAS | DELTA | SCOUT |
|---|---|---|---|---|---|---|
| INVENTORY: | | 3 | 6 | 14 | 1 | 10 |
| PAYLOAD TO ORBIT (LEO) | KSC: | 65,000 LB | 32,900 LB | 3,000–13,500 LB | 7,600 LB | 570 LB |
| | VAFB: | 28,000 LB | 27,600 LB | 1,750–2,600 LB | 5,500 LB | 460 LB |

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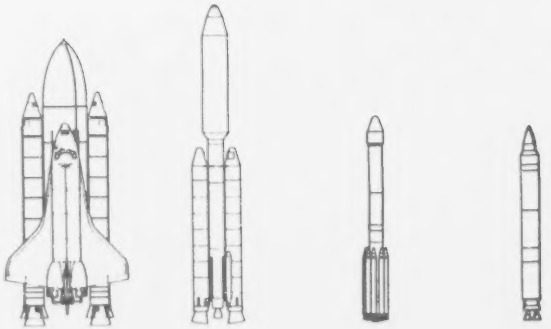
1094 2

SLIDE 5

460

# MID TERM

# RECOVERY LAUNCH VEHICLES



| LAUNCH VEHICLE: | SPACE SHUTTLE | TITAN IV | DELTA II | TITAN II |
|---|---|---|---|---|
| PAYLOAD TO 100 NM: | KSC TBD (51-58K LB)<br>VAFB — | 39,100 LB<br>31,500 LB | 11,400 LB<br>— | 5,200 LB<br>4,200 LB |
| AVAILABILITY DATE: | 1988<br>(1992 FOR 4TH ORBITER) | 1988 | 1988 | 1988 |





SLIDE 7

# LAUNCH BASE STRATEGY

- KENNEDY
  - —2 SHUTTLE PADS
  - —1 TITAN IV PAD (ILC 1988)
  - —1 TITAN 34D PAD (THROUGH 1989)
  - —2 DELTA II PADS (ILC 1988)
- VANDENBERG
  - —1 SHUTTLE PAD (FACILITY CARETAKER STATUS)
  - —2 TITAN IV PADS (ILC 1989/1993)
  - —1 TITAN II PAD (ILC 1988)

# COMMERCIAL SPACE LAUNCH

- HEALTHY COMMERCIAL SPACE LAUNCH INDUSTRY AIDS NATIONAL DEFENSE
  - —SPACE MORE ACCESSIBLE
  - —SPACE MORE AFFORDABLE
- ENCOURAGE INDUSTRY
  - —RESTRICT USE OF STS IN COMMERCIAL LAUNCH MARKET
  - —PROVIDE INCENTIVE FOR COMMERCIAL APPLICATION OF AIR FORCE MLV BOOSTER (DELTA II)
  - —ALLOW COMMERCIAL USE OF DOD FACILITIES ON DIRECT-COST BASIS
  - —WAIVE RECOUPMENT OF GOVERNMENT-FUNDED DEVELOPMENT COSTS
- GOVERNMENT/INDUSTRY SYMPOSIUM

# FAR TERM

# STAS DEVELOPED INSIGHTS
## A GENERIC ARCHITECTURE

OPTIMIZE TOTAL SYSTEM FOR LOW-COST OPERATIONS: MISSION CONTROL, LOGISTICS, OPERATIONS, AND VEHICLE

VEHICLE ELEMENTS:

UNMANNED, MODULAR, CARGO VEHICLE FAMILY (30-100K, 160K, 300K)

MANNED VEHICLE (40-65K)

REUSABLE OTV AS SOON AS TECHNOLOGY WILL ALLOW

UNCLASSIFIED

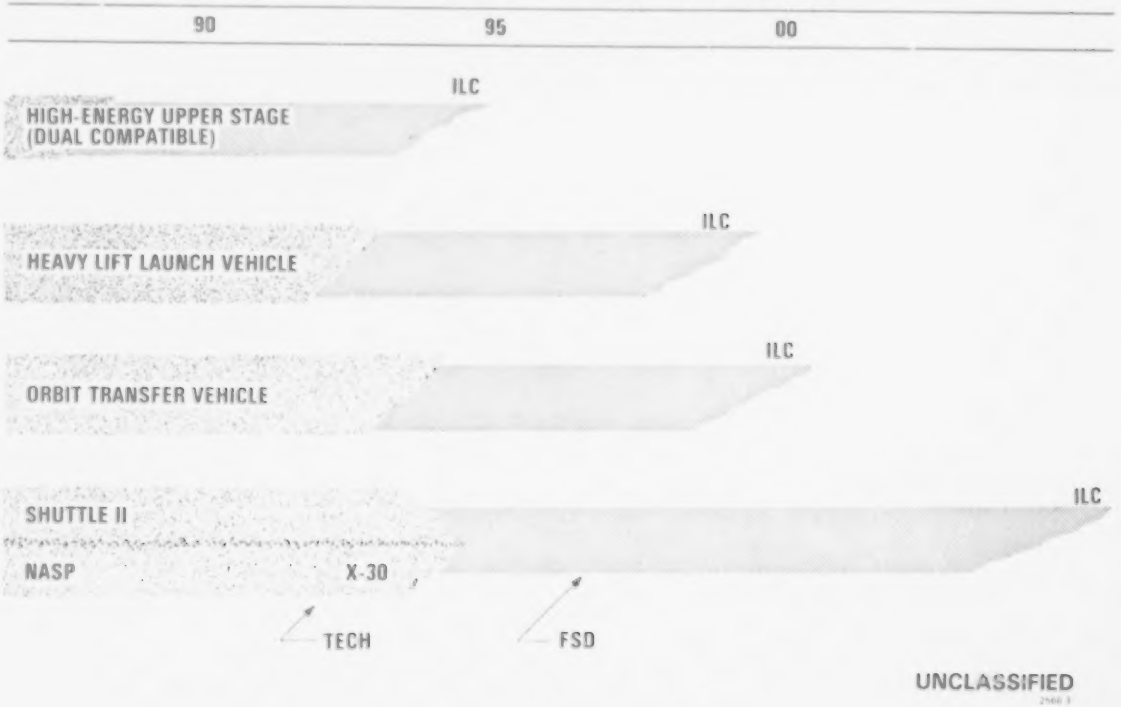


SLIDE 11

UNCLASSIFIED

# SPACE TRANSPORTATION TECHNOLOGY/ SYSTEM DEVELOPMENT

## (WITHOUT SUPPLEMENTAL)




Slide 12

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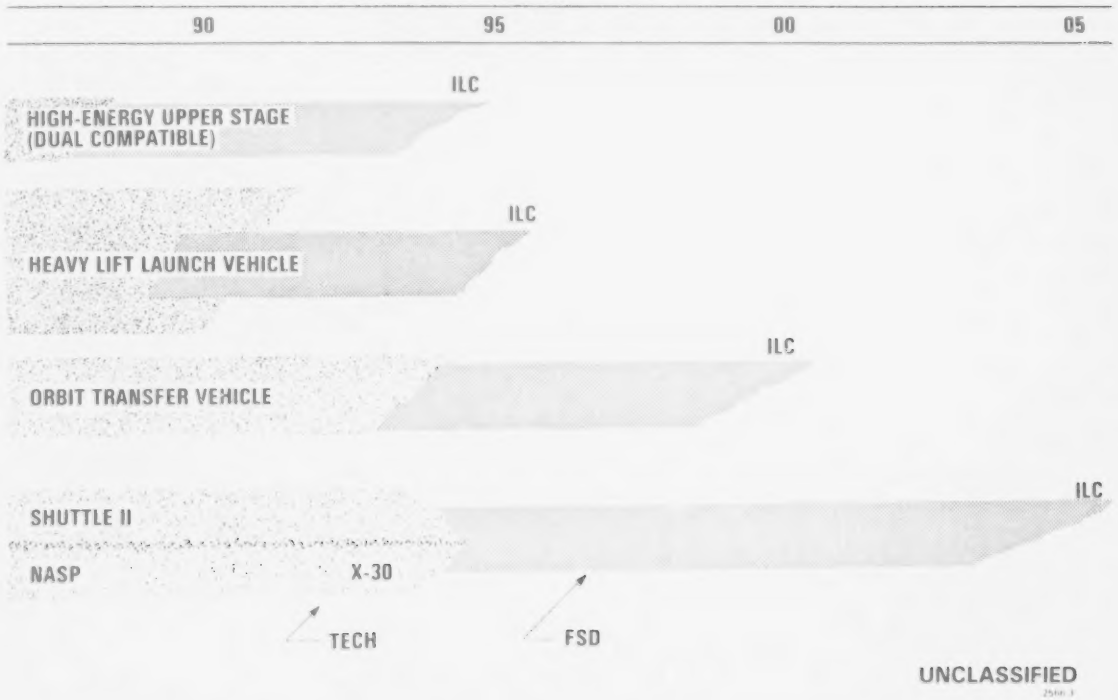
# SPACE TRANSPORTATION TECHNOLOGY/ SYSTEM DEVELOPMENT

## (WITH SUPPLEMENTAL)




SLIDE 13

# CONCLUSION

THE AIR FORCE, NASA, AND SDIO ARE WORKING COOPERATIVELY TO IMPLEMENT A BALANCED PLAN FOR ASSURED ACCESS TO SPACE FOR DOD, SCIENTIFIC, AND COMMERCIAL MISSIONS

D E P A R T M E N T  O F  T H E  A I R  F O R C E

PRESENTATION TO THE COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON SPACE, SCIENCE AND APPLICATIONS

UNITED STATES HOUSE OF REPRESENTATIVES

MARCH 1987

SUBJECT: Space Launch Recovery

STATEMENT OF: BRIGADIER GENERAL ROBERT R. RANKINE, JR
Director of Space Systems and Command, Control and Communications
Deputy Chief of Staff
Research, Development and Acquisition
Headquarters, USAF

NOT FOR PUBLICATION UNTIL
RELEASED BY THE COMMITTEE ON
SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

MR CHAIRMAN AND MEMBERS OF THE COMMITTEE:

Slightly over one year ago, the loss of the Space Shuttle Challenger shocked the Nation and dealt the US space program an unprecedented setback. The grounding of the Shuttle fleet severely impeded access to space for our country's military, scientific, and commercial payloads. Further compounding the problem were the two Titan 34D failures resulting in the standdown of this launch system since April 1986.

This series of accidents created a national crisis, one requiring development of a national space launch strategy that does not rely on any single launch system as our primary means to space. Since the tragedy, the Department of Defense, the National Aeronautics and Space Administration, other government agencies as well as the civil and commercial communities have worked intensively together to develop a plan of action that will not only recover our launch capability but place it in a far stronger position to assure our continued access to space in the future.

Our recovery strategy centers on the development of a mixed fleet of launch vehicles, and is based on several key guidelines. First, DoD will maintain its commitment to the Space Shuttle program. When the Space Transportation System (STS) again becomes operational, it will remain a key element of our launch fleet. Secondly, some missions will be selectively off-loaded from the Shuttle and moved to expendable launch vehicles (ELVs). To further promote an assured access to space capability, dual-coast launch facilities will be developed and maintained. Finally, selected military users of space will pursue satellite dual-compatibility, whereby specific satellites will be designed to fly on either the Shuttle or an ELV, as the situation warrants.

Clearly, this recovery approach demands the acquisition of additional launch vehicles, as well as development and maintenance of a national launch vehicle production and launch services industry base. However, due to the long lead-time required to produce new assets, no additional launch capacity can be provided in the near term. Therefore, the United States must continue to prioritize our existing assets -- primarily the Titan 34D, Delta, Atlas, and Scout -- efficiently employing them to satisfy national security needs. We will complement these existing assets with a fleet of Titan IV boosters now on contract for initial launch in late 1988. The Titan IV will launch Shuttle size payloads. Air Force plans also call for the modification of at least 13 existing Titan II intercontinental ballistic missiles for launch of such payloads as the Defense Meteorological Satellite Program satellites. These ELVs represent the majority of the Nation's current and planned inventory. For the most part, they are already dedicated to specific payloads and cannot be readily rescheduled. Near term Shuttle payload scheduling, on the other hand, has remained a dynamic process since the accident, with national security having the greatest influence on Shuttle payload decisions.

The recovery strategy will stress the acquisition of additional assets to close the gap between launch requirements and capabilities. Congress provided us with supplemental funding in the FY 1986 and FY 1987 budgets for 13 additional Titan IVs -- for a total of 23 vehicles -- and the medium launch vehicle. The medium launch vehicle contract for the Delta II booster was awarded in January 1987. With an initial buy of up to 20 vehicles, the Delta II is scheduled to start launching Navstar Global Positioning System satellites in late 1988. By selecting the Delta II, the Air Force is also encouraging the commercial space launch industry. A healthy commercial space industry makes space more accessible and affordable to all the Nation's needs -- military, civil or commercial.

While acquisition of additional launch vehicles greatly aids space launch recovery in the near-to-mid-term, we must also look to the future. Our far term objective is to significantly lower the cost of space launch. Further, the NASA Space Station and possible SDI deployment scenarios could drive launch requirements considerably higher by the mid to late 1990s. This drives a need for even more capable launch systems.

Alternatives for the far term are currently being analyzed in the joint NASA/DoD Space Transportation Architecture Study (STAS). The STAS contractors have been analyzing all aspects of space launch, including requirements, vehicles, operations (such as ground operations and payload processing), logistics and manufacturing processes. Technological advances will clearly be needed in areas such as propulsion, lightweight structures, automated operations, and advanced avionics. Incorporating these advances into innovative system concepts should enable the US to achieve a significantly more costeffective space launch program for the post-1995 timeframe, and possibly sooner.

For our far term strategy, the STAS points to a 1990s need for an unmanned cargo vehicle, and a post-2000 need for a new manned system to replace the Space Shuttle as it nears the end of its operational life. As the Congress is aware, the Strategic Defense Initiative Office has requested supplemental funding to accelerate the Heavy Lift Launch Vehicle. We must begin to investigate alternatives for these new more capable and cost-effective systems now if our needs are to be met in the future.

The loss of the Challenger and the prolonged grounding of the Titan 34D painfully underscored our Nation's need for a robust, balanced fleet of launch vehicles and facilities to assure our access to space. The national recovery plan I outlined above will provide the additional assets -- and planning for the future -- to ensure the Nation will never again be faced with the situation we have been faced with for the past year. It is the first step toward restoring America's leadership in space.

Mr Chairman, this concludes my remarks.

Mr. NELSON. Well, you are working cooperatively except that you want a new heavy lift launch vehicle and NASA wants a shuttle derived.

General RANKINE. Yes, Mr. Chairman, although I don't see that necessarily as contradictory. It's really a matter of how many shuttle pieces may be in the early element of the system that is on the path toward the ultimate system, and so it's been on that basis that the DOD has been seeking with NASA to determine if there is—and I think that would be in the best interests of the nation—if we can find a way to meet NASA's early requirements and also stay on a path that would lead us to an ultimate system that would have significant reductions in costs for the nation as a whole in future space launch. That would certainly be a good thing to do.

What we would like to do at this stage is just investigate that and find out if that's possible.

Mr. NELSON. Okay. Let me just cover a couple of questions here and then I'll get our members, before we get Admiral Truly back up with you.

Can you use ELV's for all of your west coast payloads instead of the space shuttle?

General RANKINE. I think the answer to that is yes, except that would not meet our policy of assured access to space, Unless we have two varieties of ELV's, which we would not now have, we would only have the Titan IV and our plans call for complementary capability from both Coasts. We would like to have shuttle and Titan IV from the east coast and we would like to have shuttle and Titan IV from the west coast ultimately, to have that assured access to polar orbits.

Mr. NELSON. By the way, speaking of that, there seemed to be a mistake in one of your charts. One of your charts was showing that the Titan IV to low earth orbit was 39,100 pounds and the shuttle was 50,000 plus pounds. This was to an Earth orbit of——

General RANKINE. 100 nautical miles?

Mr. NELSON. 100 nautical miles.

General RANKINE. Yes, sir. We showed a range of 51 to 58 for the shuttle, which is the current anticipated range of early shuttle capability that NASA has provided to us and 39.1 is the equivalent Titan IV capability from the east coast.

Mr. NELSON. I thought that we had constantly heard that the Titan IV had an equivalent of the shuttle or better performance than the shuttle. Was that just to polar?

General RANKINE. That's true from the west coast, Mr. Chairman. From the west coast, the Titan IV would have superior performance and that gets into the issues of the ways of improving shuttle performance from the west coast, like 109 percent and so forth. It turns out that the shuttle has better performance from the east coast. The Titan IV has better performance now from the west coast. Why should that be, you might ask. The reason for that is that the orbiter in a sense is a part of what gets thrown into orbit. The remaining payload is reduced more by moving from the east coast to the west coast where you no longer have the rotation of the Earth to aid in obtaining orbit. As a result, we end up with actual Titan IV performance from the west coast, which is superior to that of the shuttle.

However, there are many other things that were necessary with the Titan IV to make it approximately equivalent to the shuttle so it could perform some of those other missions. One thing was to give us a wider payload fairing. You will notice in the picture that it had a bulbous fairing on the front end. The shuttle is 15 feet wide. We had to have a Titan that was 15 feet wide so that it could carry payloads which had been designed for the shuttle, because after all, we are trying to complement the shuttle's capability.

So there is more to the issue of making that Titan IV complementary than just throw weight.

Mr. NELSON. This is not what I have been told by Pete Aldridge over the course of the last year and a half. I had no idea there was this much discrepancy in payload going into equatorial orbit. You are saying 39,000 pounds versus 51,000 to 57,000 pounds.

General RANKINE. That's right.

Mr. NELSON. In the low Earth orbit.

General RANKINE. That's right, from the east coast.

Mr. NELSON. That's a considerable difference.

General RANKINE. Well, from the west coast, the Titan IV is 31,500, it degrades from 39,100 to 31,500. What the shuttle will be, we ought to ask NASA to answer. I've received an official reply from NASA on what the east coast performance will be. As you've heard, there are many issues to be worked out on how to improve shuttle performance to get up to some level from the west coast, but because they pay a bigger payload penalty by moving to the West because the orbiter goes into orbit, it's not sufficient to meet DOD requirements.

Mr. NELSON. Okay. Why don't you tell us about your present status of the shuttle launch SLC 6 at Vandenberg?

General RANKINE. We have placed Vandenberg into what we call minimum facility caretaker status. That seems to be the most prudent level of investment to keep the option open to bring Vandenberg back to full operational capability in the future.

The easiest way to translate what we mean by the words "minimum facility caretaker status" is to say that means it takes 4 years from the decision to activate before you can have an initial launch out of there.

The reason that we think that is a prudent thing to do is that it is in our best interest to put all of our emphasis on getting the shuttle itself flying again from the east coast, where we can turn it around faster, and as you can see, it's payload capacity and capability is far greater. That will maximize the national use of the shuttle, until such time that we have established what its launch rate is going to be and what its performance is going to be. Then we can address better what missions can be flown from the west coast and at what time.

Mr. NELSON. Mr. Nagle?

Mr. NAGLE. I guess your last answer would be where I would like to take off from, back to what I discussed with the Admiral. The emphasis it seems to me seems to be so much on getting the shuttle back. I'm a little concerned that we don't get back into the same situation that we were before in the event of shuttle delay, significant shuttle delay or slippage.

From your perception, what contingency plans do we have in the event of significant shuttle delay?

General RANKINE. Well, if the shuttle would only slip a month or two, which perhaps is not unlikely, when you get up to that 11th hour and you are making the last decisions on whether things are ready to go, that wouldn't cause any changes in our DOD plans.

However, if that wasn't the occurrence it is difficult to perdict what the other occurrences would be, what is a likely problem to work. So since I can't predict it, we picked a number and we said, what would we do in DOD if the shuttle slipped one year? I don't mean to infer that one year is a likely slip at all.

But we had to pick a number that was sufficiently long so that we could see what the impact would be, because we must plan contingencies for our national security payloads.

The answer to the question is we would need nine more Titan IV's and probably some number of Delta II's but the biggest impact would be that we would need nine more Titan IV's and we would be back to the Congress with a request for an urgent supplemental in 1987 and a budget amendment for 1988 to start the long lead on the procurement of those nine Titan IV's.

Mr. NAGLE. You couldn't come back.

General RANKINE. Beg your pardon?

Mr. NAGLE. We won't know—I'm anticipating that we won't know if there is going to be a delay or not probably until January of 1988. There's no way you could come back to Congress for a supplemental for 1987.

General RANKINE. No, sir. In that case, that could cause some difficulties.

Mr. NAGLE. Now, the lead time on building a Titan IV is what, about 3 years?

General RANKINE. Four years.

Mr. NAGLE. Four years?

General RANKINE. Four years from the order to proceed to the contractor until you have a launch.

Mr. NAGLE. Within your contingency planning, is there any way in which not to put so many eggs on the shuttle basket this time?

General RANKINE. Well, we have off loaded several payloads from the shuttle, but there are some that have been designed specifically to fly only on the shuttle and could be adapted to the Titan IV only at great expense. So, what we are trying to do is keep those on the shuttle if we possibly can.

In some cases, we have been able to move those further back in the cue, in the shuttle manifest, and put earlier Titan IV launches in. In other words, switch the sequence that they might have otherwise gone in. But we are not ready to permanently move some of those off the shuttle manifest because that would be too expensive, so some of those would stay on the shuttle even though the shuttle might slip a year.

Mr. NAGLE. I'm not, you know, suggesting that we—I don't want to say that the shuttle isn't going to go or we will have a year's delay but I'm just wondering if there are any steps we could take now to better prepare—kind of like buying insurance, you know.

General RANKINE. Yes, to a certain extent. We have already—that's the reason for the contingency study and what we observed

was that some of the slack is already available in the system. In other words, the contractors have available capability to speed up but when you get up to this level of this additional nine, you would have to do such things as begin to create a second source for the solid rocket motors that go onto the Titan IV, because you would be maxing out the capacity of the current contractors to produce those solid rocket motors. You would also have to start bringing additional crews on because you would be using the launch facilities more frequently than you are at the present time.

It's not until you significantly slip, you know, as much as a year before that becomes a problem, so it is a matter of determining when the slip is announced, Mr. Nagle, and then how long the slip will be. That will determine exactly what actions you take.

We did the study to identify if there is anything we need to do right now and there was nothing we needed to do right now. So, we are content to wait a little bit longer and see how things go, but we have investigated the capability to expand and there is some capability to expand the Titan IV production.

Mr. NAGLE. I would like to go back to the infamous page 47 that Mr. Nelson spoke about earlier of the mixed fleet recommendations, you know, and that figure of 130 launches, 40 DOD launches. Have you seen that study?

General RANKINE. No, sir. I have not reviewed the study at this point.

Mr. NAGLE. That answers that question. Okay. Thank you. Thank you very much.

General RANKINE. Thank you, sir.

Mr. NELSON. Mr. Hefley?

Mr. HEFLEY. Thank you, Mr. Chairman.

General Rankine, I would like to explore the SOPC with you just a bit, if we might, also.

Now as I understand your testimony, the military is committed to the shuttle. You in no way expect to use expendable vehicles to do all your work.

General RANKINE. That's correct, sir. We learned our lesson. We ought to have dual access to space, and as I tried to show in that chart, we see a mix of shuttle and complementary ELV's of various sizes as the best means to provide that assured access.

Mr. HEFLEY. Well, you made a—or the military made, I thought, a very, very good argument when they set up the SOPC program for the need for a secure, independent, centralized command and control center for military space operations. The arguments were good.

So is the cancellation of this out of this year's budget, is that due to the fact that you don't feel you need it any longer, or simply because there are budget constraints?

General RANKINE. It's really the latter, Mr. Hefley. It's a matter of priorities. The budget was very constrained this year, and we had to make some very difficult choices. We believe the need for SOPC is still valid, but its priority was reduced somewhat by two factors that are influenced by the chain of events that we've seen happen since the *Challenger* accident.

First of all, we were contemplating being at a rate of 24 launches a year on the shuttle in the future, with about a third of those

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being DOD launches. Now we're only going to be on the order of 16 with about a third of those being DOD launches. So the number has come down somewhat.

That doesn't make the desire to have a second node go away, but it just—and it doesn't make the capacity problem go away necessarily, but it pushed it out and it lowered the priority somewhat.

The other thing is that, prior to the *Challenger* accident, we were pretty much in the process of eliminating ELV's. With the exception of the approval of the complementary expendable launch vehicle—you know, the authorization and appropriation to buy ten of those—we were pretty much closing down all of our production lines for ELV's and moving everything onto the shuttle. And so it was of great concern to us that we not have a single node for control of the shuttle at Johnson. We wanted to have a second node.

Now that we've got a mixed approach where we're using expendable launch vehicles and the shuttle, you see the urgency of the problem of a dual node is relaxed somewhat. I still think it's important. I still believe it's very important from the standpoint of all of those reasons that we gave you earlier, but I just wanted to explain, that the priority came down a little bit because of these fact-of-life changes.

As we look toward the future, I think the DOD is very interested in the role of the military man in space, and we will ultimately see a revolving requirement for some sort of control capability through which we can run experiments with military men in space.

Mr. HEFLEY. So you do feel you need it. If you had the money, you'd like to have it.

General RANKINE. That's right, sir.

Mr. HEFLEY. Is the hurricane threat in Houston a serious consideration?

General RANKINE. Well, yes, sir. Natural disasters were one of the considerations, sabotage a consideration, all of those sorts of things which are unpredictable. That was a consideration particularly, as I say, when the shuttle was, for many of our national security payloads, was the only route to space.

Mr. HEFLEY. Will you need an additional simulator in the Houston—in the Johnson Space Center?

Mr. HEFLEY. We have asked—I don't know the answer to that yet, and we've asked NASA—we've sent a letter to NASA asking them to work specifically the impacts of continuing to control DOD Shuttle missions out of Johnson.

Prior to the time that we made the decision, we had several informal contacts with NASA, as Admiral Truly has already testified, but once the decision was made, we've now gone formally to NASA and asked them for impact.

Mr. HEFLEY. Were you aware that this committee was told last year that the simulators were so filled that we would have to stop flying in August of last year, due to the lack of simulators?

General RANKINE. Sir, that was—you were told that prior to the Challenger accident?

Mr. HEFLEY. Yes.

General RANKINE. Yes, sir, because, remember, we were heading for our flight rate of 24 per year, and I think NASA will have to

ultimately answer whether the DOD's third of 16 per year, if that's where we go, will cause that same sort of difficulty.

Mr. HEFLEY. What about the security requirements for your missions as compared to the NASA missions? Will that require a great deal of change?

General RANKINE. As you know, we have a secure mode of operation out of Johnson. We would prefer some greater degree of security, but we've reviewed that, and we believe that it's adequate under the current constrained budget situation.

Mr. HEFLEY. Do you have any idea how much of this $20 million that is going to go into SOPC this year NASA will have to pick up in order to meet your qualifications?

General RANKINE. No, sir, but it will be considerably less, we've been led to believe by NASA, than the $70 million we would have been spending on CSOC operation—on SOPC operations annually.

Mr. HEFLEY. Do you have any idea when we'll get a figure on that?

General RANKINE. No, sir. As I said, we've sent a letter to NASA to give us a formal position on that. It was sent out only a couple weeks ago, and I would assume that we would get a response within a few weeks.

Mr. HEFLEY. It's my understanding that we're going to do the markup, Mr. Chairman, on the NASA budget the last of March?

Mr. NELSON. Yes, sir.

Mr. HEFLEY. It seems to me that we ought to have that by the last of March, so that we have a real feel of how much, if any, savings we're getting here.

General RANKINE. Yes, sir. As I said, we await that answer from NASA.

Mr. HEFLEY. Okay. All right, thank you very much.

General RANKINE. Yes, sir.

Mr. NELSON. Okay. Mr. Perkins?

Mr. PERKINS. General, I apologize for being a little late. I've read your testimony, and I'd be interested in just talking a little bit about a couple of things.

One is continuing to elaborate on a little something the chairman said a few minutes ago in terms of this heavy launch vehicle that we're talking about now.

In terms of the plans, I know from your little slide up there, it's very initial stage at this time, but in terms of what you're looking at, do you have any type of budgetary figures at this time as to what it's going to eventually cost in comparison with some sort of adaption of the shuttle booster?

General RANKINE. No. As a matter of fact, the Air Force and NASA are now in the process of looking at that very thing. And so I can't give you comparative figures. We're both in the process of conducting those analyses right now.

Mr. PERKINS. Do you have any sort of feel at this time whether—as to which one is going to be the more expensive?

I think earlier Admiral Truly indicated that there was apparently some additional savings that would be had by having the heavy launch vehicle in operation by a particular time.

General RANKINE. Right.

Mr. PERKINS. Is that also being taken into consideration in the economic study.

General RANKINE. Yes. Let me put it this way. What we're trying to do is find out if there is a common solution. NASA had begun—NASA was participating with us in the Space Transportation Architecture Studies and fully supported the eventual need for a heavy lift launch vehicle.

We had a more immediate need for a vehicle to help support the space station, and that, you heard, was in the '93-'94 time period. Shuttle-derived was—is a way they are looking at to do that.

We're now asking them the question. Many of the contractors who were participating in the space transportation architecture studies said, although you cannot have an entire, all-up objective system with flyback booster and so forth until the mid-1990s, that elements of that can presumably be made available sooner, if it's desired to do so.

And so it's a matter of looking at the problem in two different ways. One is, if I design my system, my ultimate system, my objective system, for low-cost launch, then are there elements of that, because they're not all that high tech, that can be made available early and meet NASA's needs

Now if I do it that way, I believe we have a higher probability that the investment we make on the early system will fit into and be a part of the ultimate system, as opposed to spending money——

Mr. PERKINS. You're saying essentially, though, you want a Type I, Type II at the same time. You work toward mission development perhaps on the Shuttle-adapted type booster, and then you continually work on and have another type of heavy launch vehicle that you have 2 years down the road.

General RANKINE. Well, sort of. What that early vehicle would be would be a component of the later vehicle. If you recall, I showed a core vehicle——

Mr. PERKINS. But what you are asking is two essential vehicles, and you're saying that—two separate vehicles, and the second one is going to be—have some of the components of the first vehicle.

General RANKINE. The first vehicle would be a component of the later second vehicle. To the core vehicle, you would add, for example, a flyback booster to make it a heavy lift launch vehicle. It would be half a heavy lift launch vehicle as a core vehicle alone, and that might have performance that would meet NASA's requirements for 1993–1994.

What we're concerned about is, if you're objective is shuttle-derived and not tied into the future low-cost program, but you're not on a path to the low-cost program—in fact, you might be on a dog leg off to the side. If you're trying to economize over the whole next 10 years, maybe it's prudent to look at whether it's possible to have the core vehicle for the ultimate system be one and the same with the Shuttle-derived.

And what we'd like to do is go out to industry with the competition and give them this problem to work, and see how many shuttle parts might end up in the solution. I think that what we'll find is that a lot of shuttle pieces may, in fact, end up in that early capability, and that might meet the reliability concerns that NASA

was concerned about, rather than going to too much high tech too early.

So all I'm saying is that I believe that if you look at it with two boundary conditions instead of just the one, there may be a solution there that would ultimately be more cost-effective for the Nation as a whole. And we've only asked NASA the question now to look at that, and it's probably not fair to ask them what their answer is yet, because we don't expect to have that for awhile.

What we'd really like to do is to go out to industry and ask the question. We'd like NASA and the DOD to go out jointly to industry, give them that problem, and see what we get back.

Mr. PERKINS. General, in terms of what you need in terms of putting it in outer space in the next several years, we've heard a lot of testimony—I think you were sitting in the first row listening when we were talking about the infamous page 47, as Mr. Nagle referred to it—in terms of additional capability, it will be necessary to place existing missions that we will have by that time into space.

Now do you believe that the present schedule, in terms of authorization of funding for ELV's, is sufficient to meet what we're going to have?

General RANKINE. Well, the DOD budget is sufficient to meet DOD needs, Mr. Perkins. I'm not prepared to comment on whether the same is true for NASA.

Mr. PERKINS. Let's go a little bit farther into the future in terms of the shuttle and the capabilities that we're looking at there.

Where are we at in terms of the development on the shuttle? What are the latest developments? Do we have any preliminary design at this stage?

General RANKINE. No.

Mr. PERKINS. I think I missed that portion.

General RANKINE. In my introductory remarks, I pointed out that what came out of the Space Transportation Architecture Study was the obvious need for a manned vehicle to replace the shuttle when it reaches the end of its useful life, but that will be well beyond the year 2000. And so we probably need to enter into full-scale development for the replacement for the shuttle in about the mid-1990's.

Between now and then, what we should be doing is investing in the technology that will open a broad range of options for that manned vehicle, and that's exactly what the DOD and NASA are endeavoring to do jointly.

Mr. PERKINS. Are you talking about some sort of adaptation of the—perhaps the technologies that we need to put the Orient Express, so-called——

General RANKINE. That's right. There are a multitude of possible approaches for the next manned vehicle. It could be totally air-breathing—not totally, because you do need something on a rocket to get into orbit or to come back from orbit, obviously.

Mr. PERKINS. So you're talking about development of a——

General RANKINE. The National Aerospace Plan we perceive as a part of the technology base for one of the options. In addition to that, NASA's Centers and the Air Force Rocket Laboratory are doing rocket research which would further advance the technology beyond what we have in the shuttle today for rocket solutions.

That way we can look at whether we want to go all rocket, whether we want to go as much air-breathing as possible, or maybe we want to have some sort of a combination where you use an air-breathing stage for the first stage and then a rocket for an upper stage—a blend, a mix.

So the main thing we want to do is not to commit to a design at this stage, because we don't need to make a decision until the mid-1990's. What we ought to be sure that we do is, to produce the technical base that will allow us to make an enlightened decision at that time. That's what the STAS study has done—identify to the DOD and to NASA what those investments need to be, and now we're endeavoring to pursue those, and that, in fact, is the basis for the President's budget request and the technology areas in NASA and in the DOD for 1988 and 1989 and the years beyond.

Mr. NELSON. Admiral Truly, would you come up now. Let me follow up Mr. Perkins'. Heavy lift launch vehicle. General, your charts show at the earliest you could have it is 1993—1995. NASA says that they probably have a requirement for 1993, if they're going to have a requirement to launch the space station. Therefore, your heavy lift vehicle, even if you poured on all the coal, wouldn't be ready for their requirement?

General RANKINE. Not quite so, sir. What I was trying to explain was that objective, heavy lift vehicle, space transportation system could not be available, at the earliest—with supplemental funding, until the mid-1990's, This 150,000 pound capable vehicle, Will use a large core, with a flyback booster as one as the notional ways of giving it that added capability. The core vehicle could potentially be available as early as 1993 to 1994. We believe it could potentially offer 75,000 pounds of lift capability, and that, we believe, would meet NASA requirements. And that's why we've asked them to join us in looking at that possibility.

Mr. NELSON. Okay. Well, I want to keep nudging you along, both of you, to require—to decide what you require, because we sure don't want a situation where NASA might decide that they've got to have a heavy lift vehicle to help get up the space station, and then the space station be delayed because we're relying on the development of a new heavy lift vehicle that would not—that would be started from scratch instead of using shuttle derived, and then it not be able to get up the space station.

Admiral Truly, if his core vehicle, were ready in 1993, putting up as he says, 75,000 pounds, how would that meet with your requirements to get up the space station?

Admiral TRULY. I think one thing to consider, and incidentally, I don't want you to judge my remarks from the point of view that NASA believes that the only way to start a low cost heavy lift vehicle is with, what we have come to know as shuttle derived vehicle, however, it is probably the simplest route to a very high reliability.

Remember, we're talking about putting a half of the Space Station, or a third of the Space Station, on orbit on one booster. So, in 1993 or 1994, some very large precious investment, and so, the highest confidence in the reliability of the vehicle will be of utmost concern. And I think that the Air Force or the DOD would be the first to agree that the shuttle derived vehicle in some form is a contender.

I personally have not seen a proposal that would give me confidence that a totally different approach, or an approach that did not take account of developed technology today, could provide such a vehicle. That's not to say that it can't. So my answer is, yes, if a vehicle of any description, that provided the appropriate lift capability of 75,000–100,000 pounds in 1993, that had the reliability that I believe that the nation needs to launch a huge percentage of the Space Station, we could use that.

I honestly believe that the simplest development path to that may be the shuttle derived vehicle, and as General Rankine said, we have a letter from Secretary Aldridge asking us to respond and to join with him in the overall heavy lift launch vehicle development. We intend to do that, although we have not responded yet. We want to be, and we plan to be, a real partner in this definition in development. We think we bring to the table, as I said earlier, a heritage of experience in test facilities and building very large heavy lift vehicles, and I think the Nation will certainly use that.

Mr. NELSON. To the both of you: Who is going to make the decision, and when will it be made?

General RANKINE. The decision will be made by the Congress, of course, when they appropriate the money. The supplemental is—and the DOD budget beyond that—would permit that decision to be made in the 1988–89 time period. So essentially, the Congress, when they vote on the supplemental, will be voting on whether they want full scale development of that Heavy Lift Launch Vehicle to begin in the 1988–89 time period.

If we were to go back to a business as usual approach, which NASA and the Air Force were talking about before the supplemental was submitted, we probably wouldn't make that decision until the 1991 time period. But the decision will be made jointly by NASA and the DOD to put it in the President's budget, and Congress will make the decision on whether or not that gets appropriated.

Mr. NELSON. And that, that would be a joint request by NASA and the DOD, and so we're talking about within a few months, if you're talking about the 1987 supplemental?

General RANKINE. The——

Mr. NELSON. Is that correct?

General RANKINE. The approval of the 1987 supplemental which you have before you already, would be tantamount to approving to go ahead with full scale development in the 1988-89 time period.

Mr. NELSON. For your concept of the heavy lift, not NASA's concept?

General RANKINE. What I feel may be one and the same. In other words, what we're really only debating is how much shuttle hardware is in this early vehicle that would be available in 1993, and how has it been planned that this vehicle will flow forward and become a part of an integrated space transportation system that will significantly lower costs. What we're trying to do is figure out what is the best way for an overall economy to the Nation of doing that. It'll be a matter of, obviously, the more shuttle parts we use, the earlier we can do it, the more technology——

Mr. NELSON. Let me stop you just there. What is the request for 1987 supplemental?

General RANKINE. The amount in the 1987 supplemental, I believe, is something on the order about $500 million, about $250 million of which is for the HLLU—approximately half for technology, and half for concept studies.

Mr. NELSON. And do you think that you have supplied us with sufficient information upon which we should go to the floor and vote yes on a $500 million supplemental for a heavy lift vehicle?

General RANKINE. I misspoke sir, it's $250 million, but I understand your concern.

Mr. NELSON. $250 million.

General RANKINE. I believe that what we're asking for here is to begin—about half of that's on technology, and I think there's good agreement between NASA and the Air Force that those are the right technologies to work on. They're the high leverage technologies for reducing costs in the future. So I think that part is well supported. It's supported by all of the studies that NASA and the DOD have cooperated on up to this point, so it's the other half, the $125 million is, should we begin now, versus begin later.

What we'd really like to do is take NASA's shuttle derived ideas, and the Air Force's—the DOD's, I should say, since it involves the SDI Organization also—take the DOD's ideas for availability of early elements of a more cost effective system, and to merge them into a single system. That's an issue which I think needs to be developed a little bit more.

Mr. NELSON. Admiral Truly, do you think that your approaches are basically the same?

Admiral TRULY. Yes, I think I agree with that. As I've said, we've been requested to join this team. We've been specifically requested to make our input to the, I can't recall the name, to the PRDA?

General RANKINE. Yes, Program Research and Development Announcement (PRDA).

Admiral TRULY. To the multipage document that will go out to industry to define the requirements. We do have some differences on the initial draft, and we intend to respond with specific changes, and as a matter of fact, I don't think there will be a disagreement because we just had a half day meeting between NASA and the DOD of this architecture study, and we talked about it, and the principal comment that we had to the words in the way that we read them, was we felt strongly about an emphasis on very high reliability, because the high cost payloads that NASA tends to have one of a kind payloads, such as a heavy Galileo, or a half a Space Station. We're going to supply our comments to that document.

We were also asked to comment on how we thought we should join the team with regard to suggestions as how, you know, other words in management and the definition and development of the vehicle, and we're going to do that. We each have a great mutual desire to get these things on the table and resolved because I think that for a national effort like this, it's obvious that it must be just that.

The problem comes in not what we each want in the long term, but how to get started for a relatively early requirement because we do not have years of time to do high technology for that first vehicle. We must depend on available technology, and in some

cases, available vehicles, in one of the various families, either shuttle, Titan, whatever.

Mr. NELSON. Let me shift gears. If you don't get to 109 percent engines, and you use steel cases, what is the payload lift estimate, Admiral Truly of the shuttle in the polar orbit from Vandenberg?

Admiral TRULY. At 104 percent, and this data does assume availability of the filament wound case.

Mr. NELSON. No, steel case.

Mr. ALDRIDGE. Pardon me, do you want me to try?

Admiral TRULY. Yes. Why don't you come up to the table?

Mr. ALDRIDGE. Shuttle system, low earth orbit, Vandenberg, polar orbit, steel case, don't have the number exactly for filament back to steel, but it's on the order of 4000–5000 pounds subtracted from the number I have here, would give me a number approximately 21,000 pounds.

Mr. NELSON. Yes, this is Arnie Aldrich, identified for the record. Just one second. Okay, the original design was 32,000 pounds, right?

Mr. ALDRIDGE. It was 32,000, I'm not sure about what the original design altitude was to compare to the altitude that this number is based on. This is 110 nautical miles.

Mr. NELSON. And you're saying it's 21,000 pounds?

Mr. ALDRIDGE. Without the 109 percent, and without the filament wound case.

Mr. NELSON. And it was 32,000 pounds without both of those as well? The original design.

Mr. ALDRIDGE. I believe that's true, and as we've known of losses along the way, the filament wound case was specifically brought into the program to balance out losses —of essentially weight growth in the total vehicle.

Mr. NELSON. Okay, let's shift gears again. In my remarks to begin with, about the space transportation system, and a mixed fleet, what are the ongoing efforts within the Administration to reassess how the shuttle ought to be used in the future? Why don't you describe for us these efforts? You talk to us about the mixed fleet, and basically that the mixed fleet should be flown, having the shuttle flown as much as possible, and then the ELV's would carry the rest, but then there are others in the Administration that are talking about that the shuttle should only carry payloads that require a man. So tell us what's going on.

Mr. ALDRIDGE. Well, first of all what's going on—the first positive thing in the next few years that has gone on is to define a shuttle manifest that specifically delineates which payloads will be used by the shuttle. The question does become extremely important, however, in the early 1990's, and I think it is a policy development issue that will have to be debated and probably will not be thoroughly debated until some more data is in, for example, as you know we do support the effort for commercialization of the ELV industry. The success, or lack of success of that effort nationally, will have a tremendous effect on the demand, and will have a tremendous effect on the pressure, and I don't mean safety pressure, but the pressure to use the payload bay capacity of the shuttle. I can give you a personal observation, is that, frankly as in all our com-

plex situations, I doubt that either of those 2 poles would be the proper one for national policy.

For example, when STS II, in looking out the back window of the shuttle into the payload bay, I saw a Shuttle Imaging Radar, side looking radar, used for geological research. It could be designed to fly on an ELV. But when there is payload space available on a shuttle mission, I think it would be foolhardy not to carry it. So to say that we would only use the shuttle for uses that involve man is a little too much right or left—I don't know whether that's right wing or left wing, whatever it is it's too far over.

But principally, I do think that the shuttle system is not going to generate flight rates that it's principle use will be and should be, associated with manned use and manned exploration of space. The flight rates are just not going to be generated at a high enough level to meet the demands that we see in the long range architecture study, even the most constrained prediction. The mixed fleet is required.

Mr. NELSON. Okay, we'll recess and be right back. Let's go over and vote, and come right back.

[Brief recess.]

Mr. NELSON. Sorry for the interruption.

General RANKINE. That's all right.

Mr. NELSON. What the Committee wants to know and we want to know if you—if DOD and NASA are communicating together about the future space policy of assured access to space, about what kind of payloads are going to go on the shuttle, what ones are going to go on ELV's, and whether or not NASA should continue to develop the filament wound booster and try to certify it to 109 percent or whether or not we ought to take all heavy payloads and just move them off onto ELV's. That's what we are trying to get at.

So, let me just ask that question. What do you two gentlemen think about moving heavy payloads to expendables instead of trying to go to 109 in a filament wound case?

Admiral TRULY. Well, in answer to your first question as to whether we are communicating, we are communicating continuously, as I said before. I believe this communication, however, in order to set the national policy that in the mid-1990's is going to take place continuously, not just between DOD and NASA, but between the Government, the Congress—and it will evolve itself.

The specific question about heavy payloads on—well, let me speak to performance. As I said earlier, the DOD has asked us to re-clarify because of confusion in numbers, the performance statements. We have those statements and it is simply a matter of staffing the letter back to them and they have asked for that date, I believe, General Rankine, by the 12th of March, and we will certainly meet that date, and as I said earlier, we would be pleased to provide that to you, you know—because nothing would help me more than to get rid of some of this confusion.

As far as all the way out to the early 1990's, we have the DOD requirements at all weights, for all programs, and are working to those requirements. Beyond that, I think this policy debate will continue.

Mr. NELSON. Beyond the early 1990's?

Admiral TRULY. Yes, I personally think that when the heavy requirements on the Shuttle to operate the Space Station come along, that is really where we have to understand the policy that you bring up about Shuttle use.

Mr. NELSON. Did you say you had the Air Force requirements and can meet all of that on the shuttle? I thought out of Vandenberg, you couldn't.

Admiral TRULY. No. I said that out through 1992, we have the Air Force requirements which today are all out of the East Coast and we can meet those requirements. We have given the DOD a lot of hard choices that they have had to make in the past year since the accident and as General Rankine said, they have been forced to off load a number of DOD missions onto the Titan IV heavy lift vehicle.

Mr. NELSON. Okay, now, would you like to state anything for the record, both of you, as to whether or not the shuttle ought to carry—let me rephrase the question.

Does anyone have a beeper? Can you turn it on so we can hear what it is?

Mr. NAGLE. I do.

Mr. NELSON. Well, since we are not going to be informed what this vote is, I will rephrase the question.

Save for the payloads that you said you could stick on the shuttle and you ought to, if there is unused space aboard the shuttle, do you feel that the shuttle should be used primarily for payloads that require a man in the loop?

Admiral TRULY. In the long term, I do.

Mr. NELSON. General?

General RANKINE. Mr. Chairman, I think the best use of the shuttle is for missions that benefit from man's presence. However, to go back to my national security need for two paths to space, from that standpoint, I need to fly some number of those high priority national security missions on the shuttle and some number on the Titan IV, so I can always assure that they are interchangeable. So, I do need, for national security reasons, assured access to space. We must have the capability to fly DOD payloads on the shuttle.

Admiral TRULY. And Mr. Chairman, incidentally, I agree with that.

Mr. NELSON. Okay. Can you all quantify for us the annual average number of missions that you would have over the next 5 to 10 years that could only be accomplished with the space shuttle? Why don't you just submit that for the record?

Admiral TRULY. We can quantify that for you, Mr. Chairman, and I'd be happy to submit it for the record.

[Information to be furnished follows:]

Material requested for the record on page 114, line 2787, by Mr. Nelson, on March 5, 1987.

QUESTION:
Can you all quantify for us the annual average number of missions that you would have over the next 5 to 10 years that could only be accomplished with the space shuttle. Why don't you just submit that for the record?

ANSWER:
Approximately 74% of NASA's payloads must fly on the Shuttle. The following tabulation is reduced from pages 17 and 18 of the Mixed Fleet Study, as briefed to this committee on January 16, 1987, and identifies NASA and NASA sponsored payloads, by number of payloads and equivalent STS flights that can only be accomplished on the Shuttle as they relate to the total payload requirements. These requirements are not met in the manifest as the STS flight rate cannot accommodate all the payloads, thus resulting in the backlog and 3-4 year slippage of payloads as illustrated in the Mixed Fleet Study.

| | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| NASA/NOAA | | | | | | | | | |
| Payloads That Could Only Be Accomplished On Shuttle | 1 | 8 | 12 | 21 | 16 | 17 | 19 | 17 | 111 |
| TOTAL NASA/NOAA PAYLOAD REQUIREMENTS | 2 | 15 | 16 | 25 | 22 | 24 | 25 | 21 | 150 |
| TOTAL EQUIVALENT STS FLIGHTS REQUIREMENTS | | | | | | | | | |
| NASA/NOAA (Payloads Accomplished Only On Shuttle) | 1.0 | 3.9 | 5.8 | 7.9 | 5.5 | 9.0 | 11.1 | 11.9 | 56.1 |
| OTHER NASA/NOAA (Payloads That Could Be Accomplished on ELV's) | 1.0 | 3.6 | 2.1 | 1.9 | 3.1 | 5.9 | 4.1 | 2.8 | 24.5 |
| DOD (SHUTTLE ONLY) | 2.0 | 5.3 | 5.0 | 5.0 | 6.3 | 4.7 | 6.7 | 5.0 | 40.0 |
| SHUTTLE UNIQUE/NATIONAL SECURITY | -- | -- | .3 | 2.9 | 3.5 | 2.9 | .2 | -- | 9.8 |
| TOTAL | 4.0 | 12.8 | 13.2 | 17.7 | 18.4 | 22.5 | 22.1 | 19.7 | 130.4 |

NOTE:

THE SHUTTLE UNIQUE/NATIONAL SECURITY PAYLOADS REPRESENT THE REMAINING CONTRACTED PAYLOADS APPROVED BY THE ECONCOMICS POLICY COUNCIL.

THE DOD SHUTTLE REQUIREMENTS ARE CONSISTENT WITH THE CURRENT DOD SHUTTLE MISSION MODEL WHICH ALREADY TAKES INTO ACCOUNT THE OFFLOADING OF DOD MISSIONS ONTO ELV's AS DESCRIBED IN GENERAL RANKINE'S TESTIMONY.

Mr. NELSON. Okay. I don't want to hold you up beyond this vote. Let's see if we can wrap this thing up.

Would you please shed and I want to give Mr. McMillen a chance here, so make your answers short on this one—what is this rumbling going on about you all assembling the orbiter, the replacement orbiter out at Vandenberg instead of the Rockwell facility?

Admiral TRULY. There is a facility at Vandenberg. It's brand new. It was intended to be used for orbiter turn around and it is available. It has not been decided to use it for orbiter production. However, since that facility is available and also there are two computer systems that are available, could be available to check at, in order to negotiate with the contractor and determine if there is an advantage to the Government in building the orbiter. We have requested Rockwell to submit in their bid options that could use—in other words, an option to build as we have before at Palmdale or to build at Vandenberg or to do the construction at Palmdale and in some fashion use that computer equipment for checkout.

We are getting that simply so that when we go through the negotiation with the contractor, we have all the facts on the table so we wouldn't delay production because we had not, you know, we had not looked at alternatives. Since we haven't received the Rockwell proposal, I frankly have no idea whether or not it will be competitive or not.

Mr. NELSON. We are going to look mighty hard at that with you. Mr. McMillen?

Mr. MCMILLEN. Just a couple of quick questions on pricing policy and your reimburseable policy. I asked some questions earlier about this, given the Committee's report that the documentation should be at the same level of detail as that of any directly funded program.

My assumption is that as the shuttle gets back on board in the out years, reimbursables are going to become a larger and larger part of NASA's budget, given the fact that we have both of you gentlemen here, it seems to me that the breakdown that you have given talks about reimbursables but it does not delineate what I see as the three different levels of reimbursables.

One is where you are acting as a contracting agent, you are really passing through, so to speak. The other is where you are providing services, that you might not have provided otherwise. The third one is really where you are actually providing something that is already there. It is sort of a user fee, is the best description of it that I might say.

My question is in fiscal 1986, I mean this is a much more substantial number than it is right now, probably in the area of your concern, over $0.5 billion, and it is going to get bigger. Are you really providing the necessary documentation for us to really understand the three different delineations that I pointed out?

Admiral TRULY. If we are not, I would certainly like to work with you or your staff to ensure that we are. The reimburseable subject has been a very confusing issue in this year because after the accident, suddenly the reimbursements that we received were for flights to fly that we couldn't fly and we had to pay them back.

Mr. MCMILLEN. Right.

Admiral TRULY. But basically we—I would categorize our budget situation into two types of reimbursements. One type is where we, for example, arrange for the flight of a DOD Fleet SATCOM communications satellite for launch on an Atlas Centaur. They pay the total cost of that. If they choose not to pay the money, we don't fly the flight. In other words, that's easy.

The difficult part to understand is in the shuttle program where we get reimbursements from many sources, under many agreements as to when they are paid and that aggregate of money is used to buy long term hardware as a portion of our ongoing operation and production, but I can assure——

Mr. MCMILLEN. It is part of your cash flow, in other words.

Admiral TRULY. That's correct, and suddenly we were strapped and it went away in two fiscal years totally. We had to come to the Congress and get help, but I can assure you that it is a complex subject but there is nothing secret about it. I would be pleased to provide people to brief you or your staff so that we could understand it.

Mr. MCMILLEN. I just want to go on the record and say that I think that would be very helpful. I mean, this is only going to get, as I said, more complicated in years to come. Truthfully, I think it would force you to also establish your pricing policies, because you can't really determine your reimbursables until you know the pricing policy and what is going to be coming in, so I think that is in everybody's best interest to do.

Admiral TRULY. We would be pleased to do that.

Mr. NELSON. Okay. We have to adjourn to go to the Walker Amendment on the Floor. We will submit any additional questions to you all in writing.

Mr. NELSON. Thank you for your patience for being with us. The Committee is adjourned.

Admiral TRULY. Thank you, Mr. Chairman.

General RANKINE. Thank you, Mr. Chairman.

[Whereupon, at 5:41 p.m., the Committee recessed, to reconvene at the call of the Chair.]

# 1988 NASA AUTHORIZATION

TUESDAY, MARCH 10, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 1:10 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. This is the fifth in a series of eight meetings that we will have as formal hearings as a subcommittee as we get ready for the 1988 NASA authorization, which at this point is scheduled to be marked up on March the 31st.

We are going to hear today from witnesses representing the important engineering and professional societies, the IEEE, the American Society of Mechanical Engineers, the American Institute for Aeronautics and Astronautics, the National Space Society together with the L–5 Society. These organizations obviously represent hundreds of thousands of scientists and engineers, many of whom contribute directly to the development, implementation, and utilization of numerous NASA programs, and these organizations certainly have a vital interest in the programs, planning, and priorities of NASA, and we look forward to hearing from these representatives.

I might share with the gentleman from Louisiana that I am on the hot spot as chairman as I never have been, because in the audience is my sweet spouse. She's going to see how her husband performs, so, Grace, we're glad to have you here.

Now there are a number of specific issues of concern to this subcommittee, and we want the witnesses to comment on this, and again I want to invite the witnesses—don't sit there and read a statement to us; talk to us. Your formal statement will be put in the record.

So some of the things that you might consider commenting on are the adequacy or not of the 1988 NASA budget request, particularly with regard to whether or not it supports research in space science and applications. For example, they make one new proposal as a science initiative, and that is the Global Geospace Science Program.

Let us hear your comments also about the increased funding in the NASA proposal of $767 million which is for the Space Station. Now basically you know that this committee has been strongly supportive of the station, but it is no secret in this town that this committee is quite upset, when all the NASA execs come before us, and they can't answer our questions, because they've been muzzled by

the White House. And when we have documents that we have spirited out of the Administration, not through NASA, that say that the cost is not as NASA has told us for the last three years, that it's $8 billion, but the document says that it's at least 16.5, if you're using apples to apples. The document also says in runout dollars, it's $21 billion.

So we would like to have some of your comments about that, not the cost just of building, but the cost of operating the Space Station as well.

We'd like to hear you tell us about the lack of funding that's requested to purchase ELV's. There are no requests in this budget for ELV's.

Now the fact is, and again it's no secret, that I am going to recommend to this committee an additional $100 million—we're going to recommend an additional $255 million, at least—but of that, there's going to be an additional $100 million to get three new ELV's, two Titan III's, and a Delta II, so that we can get up payloads such as the Mars Observer in 1990, the TDRSS V, which would go on a Titan III-4D, and then ROSAT on a Delta II. Now that's my intention at this point, to make that recommendation.

NASA came forth; they didn't have one ELV in the budget.

I want to hear some of your comments about that.

I would also like to hear your comments about the fact that the NASA budget comes forward and it doesn't have anything for the ACTS satellite. This committee has—this committee has put in for the last 3 years, and for the last 2 years, NASA has come back in their budget and has axed the ACTS.

And the proposed Civilian Space Technology Initiative, which there's a lot of support for on this committee, which is aimed at strengthening NASA programs to provide in the future critical space hardware, we'd like to hear your comments on that.

So you are welcome to comment on any or all of these items and anything else that you'd like to comment, and we're delighted to have you.

And what I thought is that we'd start out with the two of you, and then we'd just build from there, and we'd keep you at the table, and we'd get the other witnesses to come.

So we will start with Dr. Logsdon, Mr. Hieatt, and Mr. Hieatt, we'll start with you.

Mr. HIEATT. I think we'd planned to have John go first.

Mr. NELSON. Okay. If you would prefer it that way, that's fine.

**STATEMENTS OF JAMES L. HIEATT, CHAIRMAN, AIAA TECHNICAL COMMITTEE FOR SPACE SYSTEMS, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS WASHINGTON OFFICE, WASHINGTON, DC, ACCOMPANIED BY DR. JOHN LOGSDON, VICE CHAIRMAN, PUBLIC POLICY COMMITTEE, AIAA**

Dr. LOGSDON. Thank you, Mr. Chairman.

AIAA, of course, welcomes the opportunity to comment on the issues that you've raised on the NASA Fiscal 1988 budget. You know AIAA is a non-profit, by design, professional society with 40,000 members representing all segments of the aerospace industry.

We have been testifying on the NASA budget for a number of years. Our testimony this year is a little different. Recognizing the crisis situation that the Nation's civilian space program was in last year, over the last year, AIAA has done an extensive review of the Nation's posture in space and the requirements for leadership in civilian space activities. We really have tried to bring in all parts of the organization into that review, and so our testimony today is based on the best quality thinking out of the professionals who are actually doing the program.

We are about ready to publish that review, and, of course, we will submit it to the committee and hope that it will be included in the record of these hearings.

[The review mentioned above follows:]

# U.S. CIVIL SPACE PROGRAM: AN AIAA ASSESSMENT

Approved by the AIAA Board of Directors

Edited by Jerry Grey, Stanley Rosen, Johan Benson

MARCH 1987

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# PREFACE

The U.S. civil space program faces a crisis. The Shuttle, Titan, and Delta launch failures, the reports of the Presidential Commission on the Space Shuttle Challenger Accident and the National Commission on Space, the growth in overseas civil space activity, the domestic drive to eliminate the federal budget deficit, and the growth in emphasis on commercialization collectively pose a major challenge which must be addressed if the U.S. is to maintain a vital civil space program. The AIAA believes this crisis calls for a reassessment of that program.

This analysis consists of a summary and a detailed discussion of both urgent (near-to-mid-term) and selected long-term issues affecting the U.S. civil space program. These issues are presented here in four categories: restoring momentum, maintaining space leadership, organizing and managing the civil space program, and building for the future.

This paper has been approved by the AIAA Board of Directors. We hope it will be useful in determining the future course of the U.S. civil space program.

## SUMMARY

### I. Findings

It is imperative that this nation maintain a leadership role in space. A strong civil space program is essential to continued national vitality and successful foreign relations. However, the events and circumstances of 1986 lead the AIAA to conclude that the U.S. civil space program no longer has the support needed to maintain its former preeminence. This condition cannot be corrected overnight, but vigorous action backed by firm commitments *can* restore U.S. leadership in space.

The first requirement is a unified national policy which sets clear long-term objectives and makes firm commitments to their implementation. The Soviet Union, Europe, Japan, and China have made such commitments to strong space programs; U.S. preeminence cannot be re-established, nor can the U.S. participate properly in global space activities, without comparable action. There is, however, a fundamental inconsistency in attempting to achieve U.S. preeminence in space with budget policies under which civil space program funding declined sharply (in real terms) over the past two decades. If the U.S. elects to be a leading space-faring nation and to commit itself to a coherent national space plan commensurate with that objective, with the necessary space infrastructure such a plan implies, the civil space budget must be increased as rapidly as practical to a level required to support such a plan – approximately 40% greater than the present FY 87 civil space budget – and then grow at an average rate at least equal to that of the gross national product. The budget policy of the past two decades will ensure that the U.S. becomes and remains a second-class power in space. If space preeminence is a national objective, the choice is not simply to select among fixed-budget alternatives, as has been done in the past, but to formulate an achievable set of national civil space goals with measurable milestone objectives and then commit the funding needed to proceed with all the necessary actions at a pace commensurate with the attainment of those goals.

It is particularly important that those responsible for government budget policy establish a proper balance between investment funding in areas such as space, which creates future capabilities, and non-investment or sustenance funding. Both are essential, but the relative resources they receive should be adjusted to recognize that investment funds create additional wealth that can be used to pay for other essential functions without adding to the national debt.

The national perspective necessary for supporting such an approach does not exist in the administration's present policy-setting structure. A dedicated body is needed to formulate national policy independently of parochial agency interests. Whether that body takes the form of a reconstructed National Aeronautics and Space Council, a new cabinet-level department, or other organizational structure, it must have direct and timely access to the President. Its most urgent task is to assemble a firm long-term plan for the U.S. civil space pro-

gram that sets goals, defines budgets, and provides for continuity.

U.S. space leadership is currently at stake in several areas. With so few U.S. launch vehicles currently operating, foreign launchers dominate the market. Although the growing backlog of payloads and limitations on Ariane and Chinese launch rates indicate a shortage of launch capacity for several years, the picture beginning about 1992 could be very different. Unknowns that could affect the situation include reductions in projected demand (including the effects of increasing launch prices and upgrading satellite performance and useful life), an apparent revision of the Soviet role in commercial and foreign launches, availability of the advanced Japanese H-2 launch vehicle, increased Ariane capacity, and the nature of new mixed-fleet U. S. launch capabilities. Hence the U.S. must have in place by 1992 the assets needed to meet foreign space launch service competition.

Space leadership is also at stake in other commercial space activities. Strong foreign initiatives in space processing, satellite communications, and remote sensing are not being adequately matched by U.S. programs, primarily because of inadequate support for technology advancement and research facilities. There is also insufficient attention being given to the encouragement of government-industry-university cooperation, and there continues to be confusion in defining policies for commercial space ventures.

The highest immediate priority in reestablishing U.S. preeminence is to regain regular access to space. The AIAA strongly supports the recommendations of the Challenger commission in restoring the Shuttle to service, recognizing, however, that space flight activities will always involve some degree of risk. Methods for reducing this risk (for example, the now-moot proposal for vertical solid rocket booster testing, whose technical benefits were questionable, and for provision of crew escape mechanisms) must be assessed in the light of their costs and the delays they might entail in resuming flight operations. Safety, of course, remains the predominant consideration, requiring that rational consideration of risk reduction and mitigation techniques be given strong emphasis in all relevant decision-making processes.

The long-term growth of space industry requires the availability of adequate launch capacity at competitive prices. The U.S. should continue to expand its launch capacity based on a mixed fleet of expendable and reusable launch vehicles to preclude total reliance on any one launch system, so that present manned and unmanned launchers will remain operationally healthy until the next generation of vehicles is fully developed. We support the decision to use the Shuttle as the primary launcher for payloads and missions that require its unique capabilities, but it should also be used as a backup for other payloads if a suitable U.S. expendable launch vehicle (ELV) is not available. Because it is still developmental, NASA should continue to operate the present Shuttle system, but plans should be made for transfer of its operations to a dedicated entity – private, quasi-government, or government – when the Shuttle is considered to be operationally mature.

In the interest of encouraging a commercial ELV industry there should be no artificial incentives for those commercial or foreign users still eligible for Shuttle launches to prefer the Shuttle over U.S. ELVs or vice versa. In the face of continuing international competition, U.S. policy on launch vehicles should support the goal of commercial space development, including but not limited to the development of commercial launch services.

We also support the decision to begin the procurement of a replacement orbiter and structural spares. They are needed to meet the projected demand for Shuttle missions (including the backlog that is now accumulating and the expected expansion in commercialization after the space station is available), even with maximum use of ELVs. Furthermore, launch capacity will continue to be limited by Shuttle down-time and turnaround schedules, even without another catastrophic loss. Hence subsequent replacement orbiters should be built to meet demand growth, as was recommended by the National Research Council on October 9, 1986.

The cancellation of Shuttle/Centaur reemphasizes the need for a new high-performance Shuttle-compatible upper stage, as was recognized over 15 years ago, and the continuing need for increased attention to all aspects of mission safety.

Future growth in space activity, both civil and military, requires early attention to the development of more capable, cost effective, and reliable launch systems. Based on the joint DOD/NASA National Space Transportation and Support Study, the nation should proceed as rapidly as possible with the technology developments needed to select and define the preferred configurations for next-generation launch systems, including but not limited to airbreathing systems. Selection of such systems for development must be based on an integrated long-term national launch plan that best accommodates the sometimes disparate needs of both government and commercial users. Such a plan must be made independently of the present launch crisis and the constraints of short-term budget deficit considerations.

Perhaps the most urgent long-range issues facing the civil space program involve people. An essential ingredient in regaining and maintaining a vital U.S. civil space program is to restore the credibility and morale of those who manage and conduct it. Because success is the key ingredient in credibility and morale, quality assurance, reliability, and adequate logistic support must be accorded maximum attention, along with identification of achievable interim objectives and a concerted effort to create better public understanding of the real risks — and benefits — of space activities.

The future success of the space program, as with any long-term endeavor, depends on its attractiveness to the bright young people who will carry on its activities in future years. Every effort should be made to stimulate student interest at the elementary and high-school level and create incentives for faculty positions at universities, as well as to provide the educational materials and laboratory facilities needed in space science and technology. To encourage graduates to seek employment in space programs, stable funding is required to avoid the "boom and bust" cycles that have driven promising people to other fields.

A permanently manned space station is important to both near-term scientific, technical, and commercial progress and

to pursuit of long-term goals such as those proposed by the National Commission on Space; hence the program should proceed on schedule to meet the 1994 deployment date. However, NASA's program plan must have sufficient flexibility to phase in transportation support, user accommodation, and advanced technology in terms of both budget and schedule. In that regard, it is desirable to consider space-station approaches that accommodate the use of ELVs in addition to the Shuttle for deployment, resupply, and operations (including compatibility with European and Japanese vehicles), and to provide for emergency crew return, consistent with attaining initial operating capability in 1994. NASA should continue to seek maximum practical use of automation and robotics in the station design and to encourage both U.S. private-sector and foreign participation to the greatest practical extent.

Increased investment in space science is required, both for its intrinsic value to the nation and for its important role in subsequent technological development. It is essential that we continue to implement the long-term plans that have been formulated in these areas by the National Academy of Sciences and others. If the U.S. is to remain preeminent in space science, substantial budget growth will be necessary – of the order of 100% as soon as practical – as well as multiyear funding for economy and efficiency.

In space applications, primarily satellite communications and remote sensing, federal support of long-term technology advancement continues to be essential, even though these activities have been transferred largely to commercial operators. Specific actions include continued support of the Advanced Communications Technology Satellite demonstration program and implementing the existing agreement for transferring land remote sensing operations (Landsat) to the private sector.

Space technology advancement underlies any comprehensive future space activity. The present effort is also inadequate. Indeed, the present course is a status-quo caretaker path with no potential growth. New commitments are called for in key technologies such as propulsion, automation and robotics, flight computers, information systems, sensors, power generation, materials, structures, life support systems, and space processing. We support the recommendation by the National Commission on Space for a threefold increase in this relatively low-budget but extremely important area of space technology advancement, especially in view of strong foreign commitments to such technology development. NASA's Civil Space Technology Initiative is a step in the right direction.

With a vigorous, long-term commitment to space research and technology advancement, the U.S. can strengthen its activities in international cooperation. Besides its intrinsic value in generating scientific knowledge and stimulating technical growth, international cooperation also brings benefits of cost sharing, improvement in both trade and political relations, and expansion of commercial markets. Among many international opportunities (in addition to the space station) that seem especially attractive are a global consortium for civil earth observations having features similar to those of both Intelsat and the World Meteorological Organization's global weather service, and a U.S./Soviet agreement to proceed with a cooperative exploration and scientific study of Mars and other long-term science objectives. Attention must also be given to issues of global scope such as the growing danger of collision with space debris and the use of satellites for global education.

In all cooperative activities of this type, by far the best counter to foreign competition is to remain ahead in research and technology development. However, current technology transfer policy, aimed at preventing the leakage of unclassified technology, is considered by many to have adversely affected U.S. innovative potential. One action that could reverse this undesirable trend would be to continue efforts to reduce the Militarily Critical Technologies List to the minimum consistent with protection of vital classified information.

The AIAA has addressed these major issues along with a variety of others, both urgent and long-term, which have been highlighted so sharply by the space crisis of 1986. Their resolution will require a major reassessment of national policies to reaffirm U.S. commitment to leadership in space via a technically, politically, and financially sound civil space program.

## II. Recommendations

Specific recommendations made by the AIAA in this Assessment are summarized as follows:

### Restoring Momentum

(1) Recommendations of the Challenger Commission should be implemented to return the Shuttle to service as soon as possible, with safety remaining the predominant consideration.

(2) The Challenger should be replaced as quickly as practical, not 1992 as now scheduled, along with an appropriate spares replacement effort.

(3) Plans for subsequent replacement orbiters and spares should be provided, should demand growth warrant them.

(4) Launch pricing for those commercial and foreign payloads which qualify for Shuttle launches under present policies should not artificially favor either the Shuttle or commercial expendable launch vehicles (ELVs).

(5) The Shuttle should be made available as a backup if no suitable ELVs are available.

(6) Present mixed-fleet launch policies should be reexamined when the backlog has been reduced to make sure the U.S. remains competitive with foreign launchers.

(7) Government launch procurement policy should be such as to encourage commercial ELVs.

(8) Because credibility and morale are best restored by success, maximum attention must be given to quality assurance, reliability, and logistic support.

(9) Concerted efforts are needed to create better public understanding of the real risks and benefits of space.

## Maintaining Space Leadership

(1) To regain and sustain civil space leadership, NASA budgets should increase as soon as practical by 40% (over FY 87) and then grow at a pace commensurate with the gross national product.

(2) Science program budgets should be increased by 100% over those of the current year (FY 87), partly to accommodate the need for ELV launches.

(3) A balanced mix of manned, unmanned, and interactive (people plus automated and robot) systems should be used, depending on which is best suited to the task at hand.

(4) The Advanced Communications Technology Satellite program and other supporting technology programs in satellite communications should continue.

(5) The existing agreement transferring Landsat operations to the private sector should be implemented, and technology to support U.S. remote-sensing activities should be adequately funded.

(6) Funding for space technology advancement (currently less than 2% of NASA's budget) should be tripled.

(7) Multi-year funding should be made available to those civil space projects which require long-term commitments.

## Organizing and Managing the Civil Space Program

(1) A dedicated space policy body should be established that eschews parochial interests and has direct and timely access to the President.

(2) Implementation of Challenger commission management recommendations should proceed as rapidly as practical.

(3) The government should set reasonable limits on third party insurance and should serve as an insurer of last resort if no private-sector insurance is available.

## Building for the Future

(1) NASA should continue to operate the Shuttle, but plans to transfer operations to a dedicated entity should be made for implementation as soon as the Shuttle can be considered operationally mature.

(2) A high-energy reusable upper stage should be developed as soon as possible.

(3) Technology development required for next-generation space transportation systems should begin as soon as possible, following the general guidelines of the DOD/NASA National Space Transportation and Support Study.

(4) An International Space Science Board should be created to serve the same planning function as the domestic Space Science Board.

(5) The U.S.-Soviet Space Science Agreement should be renewed.

(6) A detailed proposal for joint long-term research efforts such as lunar and Mars exploration should be prepared and presented by the U.S. to the USSR at the next opportunity.

(7) The U.S. should begin exploring with its space partners the creation of an international remote sensing consortium similar to Intelsat.

(8) International initiatives should be formulated to address global problems such as space debris and global education by satellite.

(9) Efforts to reduce the Militarily Critical Technologies List should continue.

(10) Budget allocations for microgravity research, and especially facilities, should be increased substantially, and such research initiatives should be coordinated more closely among the cognizant NASA departments.

(11) The space station should remain on schedule for deployment in 1994, but its design should be sufficiently flexible to accommodate user demands commensurate with budget, schedule, and operational constraints.

(12) Consideration should be given to making space station deployment and operations compatible with both U.S. and foreign ELVs.

(13) Emergency return should be provided for the space station crews.

(14) International space-station cooperation should be strengthened; competitive pressures should be resolved by more vigorous U.S. research and technology advancement activity.

(15) Young people should be motivated to seek careers in science – and particularly in space – through a number of initiatives detailed in the text.

(16) University education and research in space-related subjects should be upgraded significantly by various methods discussed in the text.

# ASSESSMENT

## I. INTRODUCTION

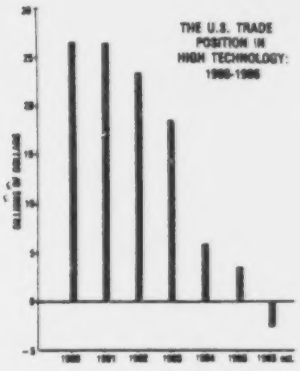
Underlying the theme of this AIAA Assessment is the fundamental premise that a vigorous civil space program is a key element in promoting both national vitality and successful international relations, and that U.S. leadership in space is essential to the strength of the nation.

The leadership role specified by the National Aeronautics and Space Act of 1958 and reaffirmed in President Reagan's July 4, 1982 space policy announcement has brought the U.S. significant economic, scientific, and political returns. Among other achievements, this country led the world in manned space flight and in exploration of the outer planets – Mars, Jupiter, Saturn, and Uranus. We created a global satellite communication system and spearheaded the first true commercial applications of space technology.

In the past decade, however, U.S. space leadership has been seriously eroded by a combination of inadequate domestic emphasis and strong support of foreign space programs by their governments. This situation reached a crisis stage in 1986 with the losses of Challenger and other U.S. launch vehicles. Following the scientific success of the Soviet, European, and Japanese Halley comet armada, the U.S. launch hiatus has offered these nations an unprecedented opportunity to capitalize on the U.S. space program weaknesses that have been building for over a decade in economically important applications (communications and remote sensing) and microgravity research, as well as in space science, technology, and transportation.

The formerly healthy U.S. balance of trade in high technology products and services has been decaying sharply since 1980-81 (see chart) U.S. Trade Position in High Technology 1980-1986, and even the traditionally strong favorable balance in agricultural products declined from nearly 25 billion in 1981 to only 7.5 billion in 1986. Although the aerospace trade balance has remained positive during this period, foreign inroads, particularly in the still-small but rapidly growing space sector, are building alarmingly. Foreign governments provide substantial support of space activities not only in the Soviet Union but also in Europe, Japan, and China, with the clearly stated intent of developing the industrial capability needed to take advantage of growing space-related global market opportunities.

Unless the government strengthens its support of U.S. space activities, particularly in the key areas of space transportation, applications technologies (communications and remote sensing), microgravity research, and advancing the basic science and technology that underlie all new development, the early U.S. lead in this important new economic area will continue to decay.




The people of this nation have seen the U.S. lose its competitive position in automobiles, in steel, in electronics, in cameras and other optical products, in clothing manufacture, and now in modern high-technology markets. The tax revenues derived from U.S. industrial capability are needed to sustain essential but non-revenue-generating social programs. Space offers the potential for significant new industrial development, but without strong federal support and investment, the attendant market opportunities will go to the foreign interests who have committed themselves to making that investment.

The AIAA recognizes the urgent need for strong government-industry-university teamwork to return the nation's civil space program to its former preeminence, with the consequent benefits both to economic return and international prestige. Although it may appear to be self serving for an aerospace organization to call for more space-program support, we believe such support to be clearly in the best interest of the nation. Federal deficits cannot be reduced in the long term without revenue growth, and investing in space has high promise for generating the future revenues needed to accomplish that goal.

## II. RESTORING MOMENTUM

### Access to Space

The first step in restoring U.S. space-program momentum is to regain and ensure regular access to space.

*Shuttle Redesign and Requalification.* The report of the Challenger commission and NASA's plan for actions to implement its recommendations are responsive to the goal of safely returning the Shuttle to flight status.

Prior to the Challenger accident NASA and Morton Thiokol had discussed a number of potential new designs for the solid-rocket booster (SRB) field-joint that caused the failure, one of which has since been selected for qualification testing. NASA had also received proposals from several contractors to study redesign of the Orbiter's main-engine turbopump assembly, and had already implemented a new landing-gear brake design due to past problems. Since the accident, NASA also initiated a further detailed assessment of all possible failure modes, as was later recommended by the Challenger commission, particularly those with no built-in redundancy. That reassessment, as well as the ongoing reassessment of other potential failure modes, should be conducted as efficiently as possible. Issues involving flight safety must be corrected, including redesign and requalification where necessary; however, overreaction must be avoided, recognizing that manned space flight activities will always include some degree of risk. Attention should be focused primarily on high-probability failure modes identified by analysis and/or test rather than be diffused into every potential failure mode.

In addition to comprehensive qualification of the new SRB field- joint design and improvement of the Orbiter's tire, brake, and nosewheel steering systems, the Challenger commission recommended that "full consideration should be given to conducting static firings of the exact [SRB] flight configuration in a vertical attitude" and to "make all efforts to provide a crew escape system for use during controlled gliding flight." However, although safety should continue to receive the highest priority, it is necessary also to recognize the national importance of providing safe and reliable Shuttle launch capability at the earliest feasible date. Hence the questionable technical benefit of such proposals as full-scale vertical SRB testing, which was eventually deemed unnecessary, and provision for crew escape mechanisms must be assessed in the light of their costs, the delays they could impose on resumption of flight operations, and particularly the implications to safety of increasing system complexity.

*Replacing Challenger.* The Challenger commission has recommended reducing the Shuttle flight buildup rates originally sought by NASA to ease schedule pressure and insure proper preparation for flight. Nonetheless, a heavy demand will continue to be placed on the Shuttle once it is flying again, including the backlog of Shuttle-unique payloads that will exist well into the 1990s, particularly space-station deployment and operation and manned defense missions. Current estimates of payload demand for Shuttle-unique and Shuttle-compatible launches in the mid-to late 1990s, coupled with realistic projections of orbiter scheduling and downtime (including the probability that at least one orbiter will be temporarily out of service due to unscheduled operational problems), clearly support the near-term requirement for a fourth orbiter, even with maximum use of expendable launch vehicles (ELVs). Hence the President's decision to proceed with the Challenger replacement was clearly justified. However, because the projected demand for Shuttle-unique missions and payload launches is not compatible with the stated replacement schedule (1992) when realistic Shuttle-fleet downtime estimates are considered, procurement should proceed at the fastest possible rate (which, incidentally, would also reduce the total orbiter replacement cost). Further, plans should be made to accommodate subsequent orbiter construction if demand growth warrants it, as recommended by the National Research Council on October 9, 1986. In any case, replacement should be accompanied by procurement of sufficient spare parts and long-lead components to avoid the shortage of such items cited by the Challenger commission in the existing fleet, and should incorporate technology advances which have been made since the existing orbiter fleet was built.

The Congressional decision to appropriate funds for the replacement orbiter over and above the planned NASA budget was essential to avoid decimation of other NASA programs. While commercial financing of subsequent replacements has been discussed at some length, it is not clear that such an arrangement is managerially tenable.

*Mixed Fleet.* Before 1984 the national policy was to phase out government-funded ELVs and use the Shuttle fleet to fly most government payloads, as well as those of foreign and commercial customers, when the existing inventory of government ELVs was exhausted. In 1985 concerns about the lack of an alternate launcher in the event of a national-security emergency dictated a presidential commitment to build 10 "Complementary ELVs" (CELV; currently designated Titan 4) able to handle large Air Force payloads. Since the Challenger accident and the subsequent Titan and Delta failures, Congress authorized 1.49 billion for Air Force procurement of 13 more Titan 4s and an initial buy of 12 Medium Launch Vehicles (MLVs) for the Global Positioning System (GPS). The Air Force has proposed an additional $2.6 billion beginning in FY 1988 to support its ELV initiatives.

It is now generally recognized that the nation needs to operate a mixed fleet composed of the Shuttle and a family of different ELVs, and that an important integral component of that mixed fleet may very likely be a private-sector ELV launch capability.

In the post-Challenger era, a substantial backlog of all types of payloads is building up. The payloads of commercial and foreign customers represent only a small part of this backlog, but a segment which could provide a business base on which a commercial launch service industry could be established. U.S. commercial launch services able to meet that demand are feasible, and are encouraged by the Commercial Space Launch Act of 1984.

The French corporation Arianespace, partly government-owned, is developing a family of Ariane ELVs able to launch a wide variety of commercial and research satellites from its launch facility near the equator in Kourou, Guiana. Despite failures (four in eighteen launches to date) and a remanifesting of future missions, the convenience and scheduling opportunities offered by Arianespace have filled its launch manifest and created a waiting list for launches through 1989. The Chi-

nese launchers CZ (Long March) 2 and 3, with geostationary-orbit capability for Delta-class payloads, are also available. The Chinese have been marketing aggressively in the West, and secured their first U.S. customer, Western Union, late in the summer of 1986. The current Japanese N-2 and H-I launchers cannot be marketed effectively outside Japan due to internal Japanese agreements that sharply limit their launch window, but Japan is developing the H-2, a Titan-3 class vehicle scheduled to become available in 1992, which may be capable of launch at any time without abrogating those agreements. The Soviet Proton workhorse has been offered for launching Inmarsat satellites (the Soviet Union is a member), but because of limitations imposed by the Soviets and by U.S. technology-transfer regulations no Western payloads have yet been committed to the Proton. That situation, however, appears to be changing, with recent aggressive Soviet moves to market Proton launch vehicles and facilities.

To date, Arianespace has launched or is committed to launch about 40% of the free world's geostationary-orbit satellites; U.S. launchers carried or will carry the other 60%. Arianespace's management has stated that the company's production, qualification, and turnaround capacity through 1991 allows a maximum of 10 launches per year (the current goal is 8), with one or two Delta-class payloads per launch. The Chinese claim they can increase their present CZ-3 flight rate (2 per year) considerably, but it is not likely that they can go beyond 4-6 in the next 3-4 years. Therefore, with Ariane fully booked, with the limited Chinese capacity, with commercial launches on the Shuttle sharply limited by President Reagan's August 15, 1986 policy, with no new U.S. ELVs becoming available until at least 1989, and in view of the growing launch demand backlog, there will be a shortage of launch vehicle capability until at least 1992.

After 1992, however, the picture could change significantly. Besides the effect of as-yet uncertain U.S. launch-vehicle capabilities, major unknowns include the capacity and launch rate of the new Japanese H-2, potential growth by Arianespace in both launch rate and vehicle upgrades, and the more aggressive Soviet marketing posture. But perhaps the most significant unknown is projected launch demand.

Downward variations in demand could occur as a result of satellite technology improvement, which has been steadily extending satellite lifetime and increasing the communications traffic that can be carried; possible delays in introducing new services such as direct broadcasting, teleconferencing, and high resolution TV; and competition in certain markets from optical fiber cables. Upward variations could also occur, however, with the introduction of a whole range of new communication services, the opening of new third-world markets, the development of navigation and position-location services, and other growth factors. The principal element in launch vehicle competition, the global demand for launch services, is therefore not well defined. Projections used in the past to justify major launcher development were grossly overestimated, and current boosters do not offer launch costs low enough to encourage dramatic increases in the number of satellite contractors seeking space transportation.

Loss in launch-vehicle business to foreign operators could also affect sales by U.S. satellite manufacturers in some cases, where foreign launchers may soon be offering "package deals" to satellite operators that include spacecraft, launch, and insurance.

Hence the U.S. must get its launch vehicles back into operation as soon as possible. Although the new business for foreign launchers in the short term will be greater than they can handle, many uncertainties beyond 1992 could leave the U.S. well behind foreign launchers, with the consequent negative impact on balance of trade. Because its present ELVs are technologically a decade or more behind the newest foreign launchers, the U.S. should also provide funding for advanced booster technology and procurement, besides encouraging commercialization of existing booster technology as fast as is economically feasible.

A nascent commercial ELV industry is ready to invest tens of millions of dollars to pursue the commercial and foreign payload market and to establish a private-sector launch capability. It will probably not do so, however, if it anticipates that it will later find itself in competition with its own government, which is also its best customer.

Past government policy, although designed to support commercialization of ELVs, has, in fact, not done so. Past Shuttle pricing policies, whatever their justification, made it unattractive for users to purchase ELV launches, even though many preferred their operational simplicity to the relative complexities of a Shuttle launch. Shuttle pricing policy for commercial and foreign payload launches prior to FY 89 had been set on a less-than-full cost basis on the grounds that the Shuttle is a national resource and that such users should pay only the costs they uniquely impose on the system. The resulting price was lower than the cost of ELV launches. And although the government has been in negotiation with private-sector ELV operators, it has not completed agreements with them regarding hardware transfer and terms of access to launch facilities and ranges.

Further, upper-stage manufacturers and some payload manufacturers who have invested heavily in Shuttle-unique or Shuttle-compatible hardware are now facing the revision of a policy in which the Shuttle was the country's primary launch vehicle to one that embraces a mixed fleet. They had, however, based their business decisions on the old policy, which had been articulated by four administrations and supported by seven Congresses since 1972.

The new policy, established by President Reagan on August 15, 1986, states that the Shuttle will be used as the primary system for the payloads and missions that exploit or need its unique capability, continuing to fly only those commercial and foreign payloads that require a manned presence or the other unique capabilities of the Shuttle or need to be flown for foreign policy reasons. However, any new Shuttle pricing policy for such payloads, reflecting the increased costs associated with reduced flight rate and other consequences of the Challenger commission recommendations, should not deter commercial and foreign customers from flying on ELVs. Such a policy would encourage development of a commercial ELV industry, to ensure that there will always be backup launch capability in the event that the Shuttle or the govern-

ment ELV fleet is grounded. The present policy should also be amended to allow the Shuttle to be available as a backup if no acceptable U.S. ELV alternatives are available, as well as when its unique capabilities are needed, and to protect against the grounding of one or more elements of the ELV fleet. Although this policy is certainly appropriate for the immediate crisis situation, it should be reexamined when the present Shuttle backlog has been reduced to make sure that users are being properly served, and that the costs of launching payloads on U.S. vehicles are competitive with those of foreign launchers.

The issue at hand is what government policies are necessary to restore a robust overall national launch capability that does not rely totally on any one launch system, and at the same time encourage a private-sector ELV industry without compromising that capability or negating the substantial investments already made in Shuttle-dependent systems. Such policies involve two factors: provision of launch services for commercial and foreign customers, and procurement of ELVs for government requirements. Government procurement and use of expendable launch vehicles to meet government requirements should be carried out so as to encourage and facilitate the development of commercial launch services, in consonance with a national space launch plan. This appears to be the case with the current Air Force MLV procurement, and is consistent with general government policy to avoid competition with commercial endeavors.

The critical dependence on still-uncertain government policy decisions is one of the fundamental problems facing all sectors of the nascent commercial space industry. Another is the unwillingness on the part of some customers, and particularly some potential government-agency users, to rely for so important a function as space launch on new and often untried organizations, because of both the possibility of business failure and their lack of experience and expertise in assuring reliability. Hence many commercial payload manufacturers and operators believe that the most rapid and politically feasible way to make a mixed fleet available to users would be to return to NASA the control of all non-DOD launches – aggregating the market, procuring ELVs, and providing launch services in a user-oriented policy framework – although some feel that without adequate budget resources and a clearly defined policy to follow, NASA is unlikely to be fully responsive to the requirements of commercial users.

Accompanying any government procurement policy should be a plan to deal with issues of timing, special circumstances, and the role of government in providing support (other than subsidy) for the transition of commercial and foreign users from the Shuttle to commercial ELVs.

## Credibility and Morale

*Credibility.* As a result of the Challenger accident and particularly the findings of the Challenger commission, NASA's former high credibility as an able organization has deteriorated seriously. Before January 1986, public expectations of performance were perhaps too great. Space launchers can never be 100% reliable, and the public and the Congress have tended to underestimate the true potential danger of space flight. The professional space community, therefore, must act decisively and rapidly to improve public understanding of the

**RESULTS OF MARKET OPINION RESEARCH POLL AUG 1-9, 1986**
(JAN 3-8, 1986 SURVEY IN PARENTHESES)

| QUESTION | AGREE (%) | DISAGREE (%) |
|---|---|---|
| Do you approve of the space program? | 70 (63) | 20 (21) |
| Should the space program be continued? | 70 (65) | 16 (21) |
| Should it be expanded? | 57 (46) | 30 (35) |
| Should space expenditure be cut? | 34 (35) | 52 (46) |
| Should we resume manned flights, with risks? | 89 | 10 |
| Should we build a new Shuttle and press on? | 85 | 13 |
| Should we fly both astronauts *and* key civilians? | 76 | 22 |
| Should we build a new permanently manned space stations? | 60 (58) | 15 (25) |
| It is important to stay ahead of USSR and Japan? | 71 (68) | 20 (21) |
| Should we spend whatever is needed to maintain space leadership? | 60 | 27 |
| Should we increase NASA budgets from 0.7% to 1% of the federal budget? | 59 | 23 |
| Should we encourage a private industry in space services? | 80 | 14 |

Source: "Public Opinion Survey on Attitudes Toward Space," Market Opinion Research, August 1986.

real risks and benefits of space, as a key element in counteracting the doubts cast on NASA's ability to carry out its programs efficiently and safely. Despite the agency's excellent past record of achievements in space science, applications, space transportation development, and the creation of new technologies, it is an unfortunate but real fact of life that an organization's ability is judged mainly on the basis of its most recent undertaking, not on how well it performed in the past.

Further, although U.S. public support for the space program, and manned flight in particular, is as strong as ever (see chart), space is not a pressing topic to the majority of U.S. citizens. NASA and the aerospace community have not been totally effective in communicating space benefits or accomplishments to the public, nor in stimulating sufficient interest among professional communicators for them to undertake that task to any appreciable degree.

Besides clarifying the real risks of space flight, therefore, the space community should undertake to reinvigorate public information and public relations programs. We should explore new and proven mechanisms to stimulate media and public interest as well as understanding. An active rather than a reactive policy is in order. The past accomplishments of NASA have not been stressed enough, nor have the many benefits of space activity such as "Earthwatch" (predicting climate and weather disturbances and anomalies) and transfer of useful space technologies to the public sector. A comprehensive communications program should be established that highlights issues appealing to a wide audience, demonstrating how an active U.S. program in space benefits the individual. Media and public understanding of space issues may be improved by promoting information resource services such as an aerospace expert group willing to respond to emergency requests by the news media for answers and explanations and by creating innovative ways for the general public to participate, even if only indirectly, in the space program. One example of such a program is the annual U.S. Space Observance Activities Week (July 16-24).

Professional technical societies such as AIAA, ASME, AAS, and IEEE can play an important role here by working together. If a consensus could be obtained on major issues confronting NASA and the space community, the united efforts of the societies could be extremely effective in disseminating the views expressed in this paper to decision-makers, opinion leaders, and news media. The societies could also form a council to award each year a distinguished international prize for contributions to the peaceful use of space, and should seek a benefactor to endow such a prize at a level comparable to that of the Nobel prizes.

NASA, of course, also has an important role in restoring momentum to the U.S. civil space program. The Challenger commission expressed serious concerns regarding questionable management and decisionmaking practices. Although many of the associated problems are a direct result of constrained budgets, which led to curtailment of the development procedures needed to assure success, NASA was a party to this process (although vigorously opposing inappropriate budget cuts), and thereby created not only a public misconception of low space transportation risk, but also contributed to the factors that led eventually to Challenger's failure. It is therefore essential that NASA focus on achievable operational scenarios and developments to implement its goals within projected costs, as well as acting expeditiously to correct the management problems identified by the Challenger commission.

*Morale.* NASA and the space community must also act vigorously to revive the high morale essential to a successful space effort.

Much of the basis for personnel morale is a strong identification with an important cause. The self-esteem of NASA's employees was closely tied to the agency's excellent reputation and epic accomplishments. In particular, the Apollo program was an incomparable prestige centerpiece, but there has been no such focus since. Neither the Shuttle nor the space station are ends in themselves.

The natural consequence of the post-Challenger criticism that the agency has undergone (both within the government and in the news media) is a loss of morale and confidence among many NASA personnel and with it some related industry-wide reaction. Although to some degree this can be turned to advantage in striving to overcome the consequences of the Challenger disaster, many skilled people, especially those who were not part of the NASA "glory days" during the Apollo program, nevertheless may tend to look elsewhere to further their careers.

This condition exacerbates a NASA personnel concern that existed prior to the accident. Many senior managers and engineers have been with NASA since the Apollo era or earlier. Hence these senior people are near retirement age and there has not yet been enough time to train the small but excellent group of young people who have joined the agency only recently. Budget cuts deriving from the Deficit Reduction Act could increase the rate of early retirements, and the new Tax Reform Act, which begins to tax at retirement those who retire after its enactment, has already stimulated such an increase.

Further, many of NASA's brightest young engineers are conducting exciting research in some of the field centers, and are not yet ready to relocate to more management-oriented functions until later in their careers.

The result of these trends is a net loss in experienced management personnel and senior engineering leadership, which could jeopardize the rapid return to efficient operational normalcy that NASA needs to restore its credibility and thereby its internal morale.

Every effort should be made to interest both young engineers and senior management people in industry to seek suitable opportunities at NASA, the latter, perhaps, on a two-year loan basis until the present crisis can be bridged. As pointed out earlier, the space community should also use whatever means are at its disposal to recreate recognition of the space program's – and especially NASA's – strengths, accomplishments, and abilities among the press, the public, other government entities, and the non-space industry, taking care, however, to avoid overenthusiastic salesmanship. The professional leadership must seek ways to reestablish the esprit of space, which had begun to dissolve to some extent even before the Challenger accident, and to motivate more strongly the

long-range planning that characterized the early years of the space program.

One prospect would be to meet the challenge of a bold dramatic mission such as a manned flight to Mars or establishment of a lunar base. Every NASA employee must be made to feel part of something important, and that his or her personal contribution is vital to the NASA team effort.

But by far the most important factor in restoring morale would be a series of successful Shuttle and ELV flights. Hence the corrective actions cited in this paper deserve maximum emphasis.

## III. MAINTAINING SPACE LEADERSHIP

As highlighted by the current space crisis, the nation's leadership must come to grips with the fundamental incompatibility between the need for U.S. preeminence in space and the present contraints on NASA and other civil space budgets. NASA cannot hope to achieve the goals delineated in the 1958 National Aeronautics and Space Act and subsequent legislation with its current and projected budget levels. The nation has a clear choice - provide the necessary funding or redefine our goals.

### A Balanced Civil Space Program

NASA's primary space-related functions are to conduct programs in space science, space exploration, advancement of space technology, space applications, and development of the infrastructure needed to carry out the nation's space program. U.S. policy recognizes that leadership in these areas is essential to national vitality and foreign relations. However, the AIAA has often expressed its concern about the balance between the resources devoted to space science, exploration, technology advancement, and applications on the one hand, and infrastructure development on the other.

There is a belief in the scientific community that the ordered plan for continuing space science progress has been derailed because of the emphasis on manned space development during the last 15 years, namely the Shuttle and the space station, although space science has continued to receive a constant fraction of the NASA budget. An additional factor is the vastly increased cost of many space science projects, a result in part from advances in technology, which allow more to be done, and advances in science, which require that more is done, often with better (usually bigger and more expensive) equipment.

In recognition of the need for defining and maintaining a vigorous role for science in NASA, the science communities over the years have developed long-range strategies such as the Solar System Exploration Committee's (SSEC's) report, "Planetary Exploration Through the Year 2000," the Astronomy Survey Committee's "Astronomy and Astrophysics for the 1980s" (the Field report), and several reports by the Space and Earth Science Advisory Committee (SESAC). The first two steps in the SSEC's report, the Venus Radar Mapper and the Mars Observer, have already been initiated (although budget pressures threaten to delay the latter), as have been the first two major recommendations of the Field Report, the Hubble Space Telescope and the Gamma Ray Observatory. But the SSEC's next mission, the Comet Rendezvous flight, did not receive its expected new-start commitment in FY 87 (although there was an important new science start, Topex), nor did the Field report's proposed Advanced X-Ray Astrophysics Facility (AXAF). With the present budget situation, it will become more and more difficult to obtain such new starts in future years.

It is essential that we continue to implement these long-term plans. This requires both multi-year budgeting and substantial growth, by the order of 100%, in space science budgets if the U.S. is to maintain its vitality in these key areas. A particular problem is the present (and future) constraint on science missions due to the limited availability of launch systems. Adequate funding for launchers is a major element of the recommended budget increase.

Those in the observational sciences (astronomy, planetary sciences, astrophysics, solar-terrestrial physics, etc.) have been the most visible public spokesmen extolling the benefits of the use of space for scientific advancement. With few exceptions (such as the man-tended Space Telescope), these types of missions are unquestionably more effectively and less expensively conducted with robot spacecraft than with manned systems, which require complex safety and life-support systems. On the other hand, science experiments which utilize the space environment (materials processing, life science, bioastronautics, etc.) in general benefit by the presence of people and can contribute substantially to the manned exploration of space. We also cannot underestimate the visibility and long-term importance of manned activities to the national spirit and security, not only in accomplishing technical objectives, but also in generating public interest, pride, and support. All space activities benefit from the existence of manned programs, as was most obvious during the Apollo program.

To carry out NASA's functions most effectively, therefore, a balanced mix of unmanned, manned, and interactive (people plus automated and robotic) systems should be used, depending on the task to be performed. NASA should not impose any artificial rules, but should determine the criteria for, and use, the most efficient and cost-effective mode for each function. For example, planetary exploration, remote-sensing operations, and operational satellite communications, at least for the near future, are functions that are best performed by unmanned spacecraft. Materials processing, life science research, and space infrastructure development benefit substantially from the efficient decision-making and responsive action abilities provided by humans. Automation and robotics technology should be incorporated to the fullest practical extent to reduce demand on the crew and to lay the foundations for future space exploration.

In space applications, NASA has an excellent record of developing infant technologies into competent, valuable contributions to mankind. The two main instances of such development are satellite communications and Earth remote sensing.

The first "communications satellite" was Sputnik I; in beeping its way around the Earth it transmitted a most important message: "I am here". One of NASA's first tasks was to raise the technological level of the primitive early satellites. By 1962, when the Communications Satellite Act was written, it was already clear that satellite communications could be a major industry, and NASA continued a sound program in technology development to support that industry for another decade.

In 1973, however, the administration decided that the by then healthy satellite communications industry could continue the technology development process on its own, and that federal technology support was no longer needed. Unfortunately, though, virtually all industry research and technology was aimed at short-term goals to improve revenues and cut costs. Technologies directed toward major long-term improvements were not pursued in the U.S., but were actively developed by European and Japanese companies with substantial support by their governments.

In just a few years it became clear that a federal role in advancing technology was critically needed, as sophisticated European and Japanese systems began to emerge. The AIAA stated that need in a 1976 position paper, "The Federal Role in Communications Satellite R&D", and in 1983 NASA proposed a new technology initiative, the Advanced Communication Technology Satellite (ACTS) demonstration program to conceive, develop, and verify high-frequency technologies in antennas, switching, baseband processing, amplifiers, and other areas.

But almost since its inception, the ACTS program has suffered from inconsistent federal budget policies. It was deleted by the administration from the FY 85, FY 86, & FY 87 budgets, and reinstated each year by Congress. ACTS is essential to maintain U.S. competitiveness with superior technologies already being integrated into foreign satellites, and should be vigorously supported.

The situation in remote sensing is perhaps even more serious, despite the remarkably successful development and use of the meteorological satellites that delivered the first benefits of space technology to mankind. The global cooperative system operated by the World Meteorological Organization is now indispensable to people worldwide.

But in land remote sensing, NASA may have been *too* successful. The Earth Resources Technology Satellite program, later renamed Landsat, was designed to demonstrate the value of remote sensing of the Earth from orbit. In doing so, NASA developed a quasi-operational system that offered its images to users worldwide at subsidized prices well below actual cost. Although a healthy value-added industry developed to process these images for specific users' needs, when it came time to transfer Landsat to the private sector, as had been done so successfully in satellite communications, there was little incentive for companies to do so without federal subsidization.

Nevertheless, after years of federal policy vacillation, one company, Eosat (a joint venture by RCA and Hughes), finally signed an agreement with the National Oceanic & Atmospheric Administration to take over and operate the Landsat system, including the building and launching of additional satellites, based on a specified schedule of federal subsidy payments. To date, however, despite strong Congressional pressure, the administration has not honored its agreement, and competition by the French SPOT system (along with potential future competition by Japanese, Canadian, and European systems under development) threatens what had been a wholly U.S.-dominated market for well over a decade. It is therefore essential that the government honor its commitment to commercialize the land-remote sensing system.

Both these instances derived in part from a fundamental problem with the U.S. civil space program: the deterioration of NASA's space technology development programs as a result of constrained budgets since the late 1960s. In August 1986 NASA's Advisory Council issued an unprecedented public statement criticizing the administration for allowing its past investments in space technology to be consumed without adequate renewal, noting that the untempered public expectation of U.S. preeminence in space has not been backed up by the requisite resources.

In recognition of this now-chronic problem, NASA has formulated a Civil Space Technology Initiative aimed specifically at remedying gaps in the nation's space technology base and developing technologies applicable to specific key systems. Technology base areas requiring urgent attention are aerothermodynamics; energy conversion; propulsion; materials and structures; data, communications, and information sciences in general; guidance and control; human factors; various space flight technologies; and systems analysis. Specific system applications for these technologies include Earth-to-orbit, and orbit-to-orbit propulsion; aeroassisted maneuvering; sensors and high-data-rate information systems; large structures (both flexible and segmented); spacecraft electric power; and robot and autonomous systems.

The National Commission on Space has recommended that budget commitments to space technology advancement be increased by a factor of three. Recognizing that this small but extremely important area consumes less than 2% of the present FY 87 NASA budget, the AIAA strongly supports this recommendation as being essential to all areas of space development.

## Budget Policy

Beginning with the post-Apollo curtailment of NASA's future plans (which had included a space station and Shuttle, a lunar base, and a manned Mars mission), civil space budgets have limited the options that NASA could pursue. Many of the factors that eventually led to the Challenger accident are traceable to the severely constrained budget allocated to so complex an engineering project. The need to complete Shuttle development under the constrained budget also led to the much-criticized contraction of major space science and applications projects and such intrinsically valuable activities as space and aeronautical research and technology and materials processing research, as outlined above. This budget policy created a steady trend toward making the U.S. a second-class

space nation. The current NASA budget is less than half (in constant dollars) of what it was in the Apollo era, whereas most other federal-agency budgets have increased significantly (see chart). This year's constant-dollar budget for housing and urban development, for example, is nearly 20 times higher than it was in the mid-1960s. Although obviously necessary, such costs often do not represent investment for future national growth, as space program budgets do.

Such policies are not consistent with the concept of preeminence. It is necessary to commit the nation to a coherent national space plan, perhaps (although not necessarily) of the type proposed by the National Commission on Space, along with the funding needed to implement both the plan's goals and the infrastructure to support them. If that plan presupposes U.S. preeminence in space, as the AIAA strongly believes it must if the U.S. is to remain a political and economic power, the civil space budget must be increased as quickly as practical to about 40% greater than the FY 87 level, and then grow at a rate at least equal to that of some measure of the economy; for example, the gross national product.

This action requires a major political commitment by the administration and full support by the Congress, because the additional funding is required during a period when all federal budgets are under severe deficit reduction pressure, particularly the budgets for discretionary expenditures such as NASA's (in contrast to relatively fixed entitlement expenditures).

It is particularly important that those responsible for government budget policy distinguish between investment funding, which creates future capabilities, and non-investment or sustenance funding. In recent years the U.S. has experienced difficulty in competing internationally in traditional manufacturing sectors with foreign producers who enjoy low labor and other costs. Hence the U.S. must seek to compete in higher technology areas. Many other governments recognize this and do provide support for high-technology development as a matter of government policy.

Space is a prime example of high-technology development. The U.S. government should therefore recognize civil space expenditures as an investment in the future industrial competitiveness of the country, and increase them appropriately as recommended above. Particular emphasis should be given to those areas where U.S. preeminence is essential to the national interest.

Further, most major space projects require long-term commitments, generally of the order of a decade or more. Such commitments are not compatible with annual budget authorization and appropriation processes. For example, cancellation of the U.S. commitment to a twin spacecraft for the multi-year solar polar Ulysses mission after Europe had implemented its commitment created mistrust on the part of the European Space Agency, which is reflected in current space-station negotiations with the U.S. Hence we strongly recommend that NASA be authorized to make multi-year budgetary commitments (as have been approved for major DOD projects).

## IV. ORGANIZING AND MANAGING THE CIVIL SPACE PROGRAM

### Formulating Space Policy

When NASA was created in 1958, the need for a top-level policymaking body was recognized by establishing the National Aeronautics and Space Council, chaired after 1961 by the Vice President. The Council was later abolished, and its space functions are now carried out by the Senior Interagency Group - Space (SIG-Space). The Commercial Space Transportation Act of 1984 established an Office of Commercial Space Transportation in the Department of Transportation to imple-

**COMPARISON OF FEDERAL AGENCY OUTLAYS**

(BILLIONS OF 1985 DOLLARS)

| Agency | 1965 | 1970 | 1975 | 1980 | 1985 | % Growth (85-65) |
|---|---|---|---|---|---|---|
| Agriculture | 21.7 | 21.6 | 29.5 | 45.9 | 55.5 | +156% |
| Commerce | 1.3 | 2.0 | 2.0 | 4.1 | 2.1 | +66 |
| Defense | 152.9 | 206.1 | 163.1 | 172.9 | 245.4 | +60 |
| Education | 3.7 | 12.1 | 14.3 | 19.5 | 16.7 | +354 |
| Energy | 8.0 | 6.1 | 6.1 | 8.5 | 10.6 | +32 |
| Health & Human Services | 69.1 | 75.7 | 197.9 | 256.4 | 315.5 | +356 |
| Housing & Urban Development | 1.5 | 6.2 | 14.3 | 16.8 | 28.7 | +1771 |
| Transportation | 17.4 | 17.3 | 19.1 | 26.1 | 25.0 | +44 |
| Environmental Protection Agency | .4 | 1.0 | 4.8 | 7.4 | 4.5 | +974 |
| NASA | 15.9 | 9.6 | 6.2 | 6.5 | 7.2 | −54 |
| Total U.S. Government | 368.9 | 502.8 | 631.4 | 780.0 | 946.3 | +157 |

SOURCES: Office of Management and Budget (FY 87) and Congressional Budget Office.

ment the commercialization of ELVs, and the President has created an Interagency Commercial Space Working Group within the Economic Policy Council to implement other space commercialization thrusts. International interactions in the space field involve NASA, the Department of Commerce, and the Department of State, but their interaction has not been formalized other than indirectly through SIG-Space and the National Security Council.

NASA and the Air Force have worked together successfully for years on projects of mutual interest. Because there is a significant degree of military-civil commonality in launch vehicles, launch facilities, spacecraft, communications, and sensor technology, this long-standing policy for cooperation in sharing technology development, facilities, and launch-vehicle development and use should be encouraged to maximize their utilization and avoid duplication.

NASA's main avenue for participation in administration policy is SIG-Space. However, because SIG-Space is composed of individuals who represent the specific parochial interests of their own agencies (Depts of State, Treasury, Defense, Justice, Commerce, and Transportation, as well as OMB, CIA, the Joint Chiefs, the Office of Science & Technology Policy, and NASA), there is no unified motivation to create policies which benefit the nation as a whole. This was most clearly evident in the many months of indecision following the Challenger accident. Therefore a separate dedicated body should be created at a high level in the administration to replace the coordination and policy functions now conducted by SIG-Space. Several of the potential mechanisms for accomplishing this which have been suggested, such as reestablishing the National Aeronautics and Space Council or creating a cabinet-level space agency, would be suitable, but the primary purpose of this action should be to avoid the present parochialism and to provide direct and timely access to the President. Among the tasks facing the new body are developing and implementing a comprehensive long-term civilian space program, coordinating all national and international space activities, and resolving key policy issues such as a coordinated U.S. approach to launch vehicles.

## Transportation System Management

The events of 1986 underscored a number of long-standing problems with NASA's space transportation system management. Specific concerns identified by the Challenger commission included decentralization of management authority within the agency, the lack of former astronauts in management positions, inadequate safety review authority, inadequate communications on Shuttle operational problems, and an inadequate quality assurance management structure.

Since the accident, the NASA Administrator presented to the President a report on the actions taken to implement the Commission's recommendations. Specific actions related to space transportation management include an assessment of overall NASA program management, assessment of the Space Shuttle management structure (including the relationship between the program office and the field centers), and establishment of a Shuttle Safety Panel with direct access to the Space Shuttle Program Manager.

Several astronauts have been appointed to key management roles, including that of Associate Administrator for the Office of Space Flight. Among the actions urgently required of that office are creation of a plan for space transportation system operations and future development that reflects the occurrences of 1986, in cooperation with the Defense Department and the overall space policy body (see above). Subsequently the Associate Administrator needs to develop plans to ensure commercial ELV launch-related quality assurance and safety (in cooperation with the Defense Department), for space-station transportation during development, deployment, and operations, and ultimately for transition of space transportation operations to a dedicated operations entity when warranted.

Although the nation will no longer rely solely on the Space Shuttle as its primary space transportation system, it nevertheless will represent a key element in the U.S. space transportation fleet for at least the next ten years and possibly longer. But even prior to the Challenger accident, NASA had begun to experience problems in meeting its prescribed launch schedule. These problems included inadequate training time for flight crews, excessive overtime work by Shuttle processing personnel, lack of adequate spare parts, abridgement of critical component maintenance procedures, difficulties with orbiter landings at the Kennedy Space Center, higher replacement rates of critical components than were planned and budgeted (e.g., main-engine turbopump elements), etc. Since the accident questions were raised as to the adequacy of flight readiness reviews, the decision-making process involved in imposing and removing launch constraints, and the overall internal communications process related to launch decisions prior to and during the countdown.

To correct these problems, the Challenger commission recommended a reduced flight rate to decrease the schedule pressure; using Edwards as an alternative to Kennedy for landing whenever weather is unpredictable; and improving the processes for defining launch constraints, conducting flight readiness reviews, improving maintenance procedures, and opening internal communications channels.

NASA should also assess the value of significant investments to reduce Shuttle operations and maintenance costs and increase system availability by adequate logistics support and by product improvements associated with engine and orbiter refurbishment such as turbomachinery life, engine performance level and reliability, logistics, and thermal protection. A backup Shuttle carrier aircraft should be provided, in part to support the additional landings at Edwards.

Because of factors such as the limitations of a three-orbiter fleet, the Air Force has decided to put the Shuttle launch complex at Vandenberg on a caretaker status until 1992, and have the military use instead a combination of expendable vehicles out of Vandenberg and Kennedy and Shuttles out of Kennedy. If there continues to be a projected requirement for polar manned missions (e.g., servicing of polar-orbit space-stations or other platforms), the nation will need to bring the Vandenberg Shuttle launch complex to operational status in time to prepare it for such activities.

### Safety and Quality Assurance

The Challenger commission recommended that NASA establish an Office of Safety, Reliability, and Quality Assurance headed by an Associate Administrator reporting directly to the NASA Administrator, to be responsible for "The safety, reliability, and quality assurance functions as they relate to all NASA activities and programs" The NASA Administrator has since appointed such an Associate Administrator.

However, simply adding more inspectors and procedures may, in fact, introduce delays, higher costs, and divided responsibilities. It is necessary that the new Associate Administrator fully recognize the need to motivate quality- assurance personnel (and, indeed, all who work on the nation's space program) to restore their dedication to performance and the pursuit of excellence, and to upgrade methods, equipment, training, and incentives to attract the best new people.

It is also important to recognize the vital role *technical* management plays in quality assurance, both through the creation of "forgiving" designs and proper qualification testing in the first place, and through careful and independent technical reviews during all phases of design, development, test, and operations.

### Insurance

The insurance losses incurred in recent years (since the mid-1970s) by launch and in-orbit failures have amounted to almost $900 million, less than $500 million of which was covered by premium payments. Although the 1986 launches of Challenger, Titan, and Delta did not carry insurable payloads, their failures compounded the insurance dilemma. As a consequence, the insurance pool available for a single flight has shrunk to about $90 million, less than the cost of a typical single satellite and its launch, and far less than the insurance required for multiple payload launches. Further, underwriters will not write a policy more than 90 days prior to launch, to keep rates current. The result is that lending institutions will not issue loans to satellite owners or operators without insurance as a factor in repayment in the event of a launch failure. Consequently, only large corporations or governments that have the resources to sustain large losses can afford to buy and operate satellites. However, large corporations that can obtain financing are reluctant to make investments without insurance coverage, because launch failure would be catastrophic to the corporation. Both Arianespace and the Chinese provide insurance to their customers, if necessary, with government backing and support.

The Departments of Commerce and Transportation should encourage rejuvenation of the launch and spacecraft insurance industry, and the Department of Transportation should set reasonable limits on third-party liability for commercial ELV operators. The insurance industry, in concert with spacecraft manufacturers, spacecraft operators, and launch vehicle operators, should design its own structure for recovery to bridge the present capacity and structural shortfall. However, the government should consider the prospect, on an emergency basis until acceptable launch and satellite failure rates have been reestablished, for servicing as insurer of last resort; that is, if a spacecraft operator is unable to secure sufficient launch and liability insurance in the commercial marketplace, the government, in cooperation with other governments where appropriate, would provide insurance during a defined transition period, but at a premium rate considerably above that available in the open market.

## V. BUILDING FOR THE FUTURE

Although regaining civil space program momentum certainly ranks highest in immediate priority, failure to plan properly for the future could bring the U.S. once again into a situation comparable to that which now exists. Hence it is necessary to begin *now* the planning process to resolve both near-term and far-term civil space program issues. Some of the key areas which require urgent attention are addressed here.

### Space Transportation

*Launch Operations* Contrary to early expectations, the Shuttle must still be considered as a developmental program, has yet to achieve mature operational status, and therefore must continue to be operated by NASA. During this time it can be viewed as a national facility, much like a NASA wind tunnel, for use in furthering the space interests of the nation.

In 1985 the National Academy of Public Administration was asked to examine the feasibility of a government corporation within NASA to conduct Shuttle operations. The study concluded that it was feasible but not warranted. Shuttle operations management has been studied extensively in the past 15 years, and most studies have concluded that Shuttle operations are still best done by NASA.

However, the continued addition of long-lived facilities to NASA's cognizance, whether for infrastructure or for science, captures more and more of the budget and limits new initiatives. Therefore, at such time as the Shuttle becomes operationally mature, consideration should be given to transferring its operations to a separate organization dedicated to that function.A concept proposed at AIAA's June 25-26 ELV workshop, for example, and subsequently by the Congressional Budget Office in October 1986, would place *all* U.S. space launch activities in the hands of a national space transportation company similar to Arianespace, whose owner would be the U.S. government and private-sector manufacturers, operators, and users of space launch systems. However, such a concept, which requires legislation comparable to the Communication Satellite Act of 1962, would take at least several years to implement. Should unforeseen difficulties arise in formulating a viable quasi-government corporation of this type, Shuttle operations (and, indeed, perhaps all operational aspects of the civil space program) could be turned over to a federal agency, perhaps NASA, but such operations must be specifically organized for that purpose and clearly separated from NASA's basic R&D function.



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*Upper Stages.* The original plan for the U.S. space transportation system included a high-performance reusable "space tug" called the Orbit Transfer Vehicle (OTV) for access to orbits beyond the Shuttle's. Budget constraints delayed this approach, and the DOD agreed to develop an interim system. The Air Force funded the development of the "Interim Upper Stage (IUS)". Its capability was then expanded to meet longer-range requirements, whereupon it became the "Inertial Upper Stage." Meanwhile, NASA encouraged several private-sector developments of expendable orbit transfer stages. Some integral orbit transfer propulsion systems for spacecraft have also been developed.

Modifications to the IUS had been planned to deliver Galileo and Ulysses missions, and these developments proceeded through preliminary design. In 1982 NASA decided to develop a Shuttle Centaur to perform these missions. Two versions of the high-performance Centaur were planned.

In June, 1986, NASA elected to cancel use of Centaur in the Shuttle, primarily due to safety considerations. NASA is developing alternative scenarios to meet the planetary requirements in the near future.

Agreement is required as soon as possible on the configurations of existing launch vehicles and upper stages, incorporating modifications as required, to fill the high-performance gap left by the Centaur cancellation. In the long term, NASA and the DOD should initiate the development of a reusable high-energy stage for the Space Shuttle, and ultimately as an element of the space station. This development could be undertaken in phases; that is, qualify the stage first as expendable, then as reusable, and perhaps eventually as man-rated. Technology demonstrations such as an OTV aerobrake experiment should be implemented to improve that technology base for development of future systems.

*New Launcher Development.* It has long been recognized that the extensive space operations projected for the future, both civil and military, will require increases in payload weight and, especially, significant reductions in the cost of placing payloads in low Earth orbit and beyond. Development of such next-generation launch systems is one of the principal recommendations of the National Commission on Space. The National Space Transportation and Support Study conducted by DOD and NASA to define the next-generation national space transportation system needs, based on a broad range of mission requirement scenarios, has already concluded that a new unmanned launcher, a new manned launcher, a reusable orbit transfer vehicle, and new approaches to operations will be needed. The study examined various alternatives for new launcher development, including conventional multistage expendable rockets, two-stage and single-stage-to-orbit reusable designs, and aerospaceplane concepts, but did not select a specific approach because the U.S. has not yet established a sufficient technological base to allow a choice between advanced-technology design alternatives. The U.S. has also initiated a multiyear aerospaceplane research effort, with flight testing of a research aircraft planned to begin early in the 1990s.

Significant international launcher capability is available or is being developed. Japan, China, the Soviet Union, and ESA/Arianespace partners are all proceeding with advanced launch system developments. Aggressive U.S. action is required to counter these developments to maintain a healthy U.S. competitive position in the future commercial launch services market, as was pointed out earlier.

The decisions needed to pursue next-generation space transportation developments must be based on an integrated long-term national launch plan that best accommodates the disparate launch transportation needs of both the government and the commercial user communities. It is essential that long-term development decisions on the next-generation launchers be made independently of the present launch crisis and the constraints resulting from short-term budget deficit considerations.

NASA and other agencies involved in space activities should work collectively to build on the results of the current space transportation architecture study in defining the launch capabilities needed to re-establish and maintain U.S. leadership in space. The administration should then proceed as rapidly as possible with technology developments necessary to select and define preferred configurations for next-generation launch systems, with attention given to ensuring backup in the event one system is grounded.

Expenditures for advanced space transportation system technology have been constrained to a very low level for over 15 years by a combination of high expenditures for Shuttle development and deployment and relatively flat NASA budgets. Recent failures of the Shuttle, Titan, and Delta will increase near-term investment to develop fixes and replace Challenger. A broad-based technology resource exists, is posed for major advances, and could be applied to accelerate space transportation system development. Emerging new technologies offer prospects for major improvements in performance, cost, automated operations, and reliability, but are not being vigorously pursued because of lack of funding and trained, experienced personnel.

Advances in space transportation system technologies in areas such as chemical propulsion, materials, structures, and unconventional concepts will be required for selection of and application to the generation of expendable and reusable launch vehicles in the mid-1990s and beyond. It is essential that NASA reinstate its fundamental research and technology advancement programs in these areas, including but not limited to those associated with the aerospaceplane, directed toward maintaining a U.S. competitive launch-vehicle edge in the 21st century. It is also essential that DOD continue technology advancement programs in its areas of interest.

In pursuing the selection and definition of next-generation launch options, mission requirements based on the needs of both civil and DOD programs, including the demand which may evolve as a result of the Strategic Defense Initiative (SDI) effort, should be used to size and otherwise define these launch systems.

## International Involvement

U.S. activities in space put it in competition with other countries, but many space activities benefit from international

cooperation. Further, space cooperation and competition can enhance U.S. foreign policy. In the future, the U.S. will continue to be involved in both cooperation and competition.

NASA has carried out over a thousand space agreements with more than a hundred countries for various cooperative activities in space. Such agreements have worked to advance U.S. interests in many ways.

Cooperation in space activities can save money through cost sharing, can open new markets and avoid confrontation and cut-throat competition in certain fields, and is the logical procedure when dealing with such problems as weather and environmental pollution, which extend beyond our borders. Other opportunities for cooperation, discussed in greater detail later, include control of space debris, Earth observation, space science, the space station, Mars exploration, and cooperative utilization of launch systems.

Various factors limit the extent of international cooperation; for example, national security, national prestige, technology transfer, regional or political blocs, restrictions attached to funding commitments, and economic/competitive advantages. However, the benefits of international cooperation in terms of cost sharing, improvement of both trade and political relations, and widening of commercial markets is today more important than ever before.

*Science.* Starting with the International Geophysical Year (IGY) in the late 1950s, international cooperation in scientific missions has continually increased and represents an area where many parochial boundaries have been crossed successfully. Exchanges of data and international response to instrument Announcements of Opportunity have been prevalent. A Soviet/US Space Science Agreement, which expired in 1982, was also fruitful. On the negative side, U.S. withdrawal from programs that it initiated, such as Ulysses (then the International Solar Polar Mission), have introduced a cautionary note in ESA's subsequent participation. To date, foreign participation in our planetary programs has been minimal, permitting undiluted U.S. prestige gains. Thus, it appears that some improvement in our scientific relationships with foreign organizations could be made. For example, we should promote more vigorously our scientists' participation in foreign programs. Many present mechanisms exist for doing so, both governmental and nongovernmental, but it may be useful to establish an International Space Science Board similar to our indigenous one. A necessary ingredient for improved cooperation requires that some mechanism be created for committing budgets over several years so we would not be forced to renege on our promises.

The U.S.-USSR Space Science Agreement should be renewed. To reinvigorate the process of U.S.-USSR collaboration in space science, there is an obvious opportunity to coordinate the forthcoming 1989 Soviet mission to Phobos with the subsequent U.S. Mars Observer flight. A follow-on opportunity could be a cooperative Mars sample return mission.

Another excellent opportunity for near-term cooperation with the USSR is the International Solar-Terrestrial Physics program (ISTP). ISTP is currently a US/ESA/Japanese program in which each participant provides at least one spacecraft with the overall objective of making detailed measurements of the Sun, the solar wind, the magnetosphere, and the ionosphere. The USSR could contribute one or more spacecraft to ISTP, perhaps their concurrent INTERBALL program. Other possible near-term U.S./Soviet cooperative activities would involve manned missions; for example, exchange of crews between the Shuttle and the Soviet's Mir space station, demonstration of rescue of cosmonauts or astronauts, installation of U.S. experiments on Mir and Soviet experiments on the Shuttle or space station, and the carrying out of joint experiments in the life sciences that could bear on tests critical to a future manned Mars mission.

The groundwork should be laid now for a U.S. proposal incorporating these elements, perhaps leading to longer-term programs such as a cooperative manned flight to Mars, a scientific outpost on the Moon, or extending the search for extraterrestrial intelligence. Such a proposal should be offered at the next opportunity.

*Earth Observations.* The observation of the Earth's atmosphere, oceans, and land has been conducted from space for more than 25 years. That experience has demonstrated incontrovertibly the utility of these measurements, and essentially all the nations of the world employ space-derived data on a daily basis. Further, the technology upon which the measurements are based now exists in a large number of countries. Thus, the desire to obtain data, the capability to exploit them, and the technological skills to create them are now globally distributed. Finally, the data themselves respect no national boundaries. They depict natural and manmade conditions of great human and economic importance, and conditions which frequently transcend political boundaries.

The expanded application of these data to human needs, both physical and intellectual, is impeded not by data interpretation, technological feasibility, or even further market development, but rather by the underlying system economics. On the one hand, the nations of the world are cooperating in the sharing of meteorological and oceanic data and of the cost of system manufacture, and on the other several nations are planning or building duplicative, overlapping systems. While the latter situation is tolerable for the early years of a nation's space program, the former is a better model for the future, and for the whole of Earth observations.

System economies can be improved by the elimination of duplicative systems, the reduction of overhead costs, expansion of the market, and potentially the use of astronauts for system repair and replacement. The first three of these were successfully achieved in satellite communications by Intelsat. The last may be a byproduct of the Space Shuttle, space station, and Hermes programs, to the extent that polar-orbiting capability is provided.

The inherently global science of Earth observations, encompassing all of the disciplines (meteorology, oceanography, geology, etc.), is accompanied by global needs and capabilities, and offers the opportunity for enhanced international cooperation and the shared economic gains mentioned above. This can be accomplished through the creation of an international consortium for Earth observations that is modeled on

Intelsat. Initial membership could include the member nations of the European Space Agency, Japan, the United States, and others. The responsibility of the entity would initially extend to the provision of Earth observations (atmosphere, ocean, and land) and related services from sun-synchronous, near-polar orbit. Related services would include data collection and search-and-rescue. Ultimately, the responsibility could grow to include a ring of geostationary environmental monitoring satellites as well.

Such an organization could also serve the science community, as many Earth- sciences research issues must be addressed by a combination of long-term operational and targeted shorter-term research instruments. Further, its spacecraft would provide a convenient marshalling point for selected research, as well as operational, instruments.

The United States should therefore begin discussion with its current space partners to start the process for the establishment of a new international commercial consortium for Earth observations.

*Space Debris.* Another potentially valuable area for international coordination is the growing problem of space debris, with which AIAA has been concerned for over seven years. The Institute's July 1981 position paper "Space Debris" predicted that the problem would become serious in the 1990s if proper steps were not taken. Recent data clearly support that prediction. A new factor is the potential effect of SDI and comparable Soviet experiments.

Precautions to reduce the growth of space debris could be taken by international agreement; for example, venting all pressure vessels at the end of their life, capturing all explosively-actuated devices, assuring timely Earth entry of all abandoned low-Earth-orbit spacecraft, etc. These and other anti- debris methods would only be effective if adopted on an international basis. However, before the U.S. pursues international adjudication of the space debris problem, a national policy must be developed, after which establishment of international agreements should be sought to provide guidelines for acceptable control and disposal of space debris.

*Global Education.* One of the major opportunities for international involvement in the 1990s is global education by satellite. The United States is in a good position to assume a leading role.

The need for an international approach at all levels of education throughout the world is evident, and it is urgent — even desperate – for adult populations in many developing countries. As demonstrated by the Advanced Technology Satellite program and others, satellites can be used increasingly for education in hygiene and public health, agricultural methods, language, and social inter-relations. Space instruction at higher levels needs to be provided in biology and medicine, chemistry and physics, geology and hydrology, and various applied sciences. An important example in medicine is the use of satellites for immediate assistance in diagnostics and in carrying out surgical operations with complications when a physician who has international credentials resides in one country and the operation is conducted in another. Programs in the arts and entertainment could also be exchanged on a regular basis and language barriers breached. Clearly, an international effort needs to be established to promote the use of satellites for broad aspects of education throughout the world, especially in developing countries, with easy access and low cost.

*Technology Transfer* has long been recognized as one of the most difficult aspects of international cooperation. Much has been written about the adverse consequences to security and commercial competitive position as a result of the leakage of American technology to other nations, friendly and unfriendly. Protective measures designed to minimize the loss have, in some instances, caused negative results in the U.S. itself. For instance, a penalty is imposed on U.S. scientists, engineers and graduate students, and therefore U.S. innovative potential, by the substantial reduction in recent years in the flow of open unclassified information on some of the most interesting and important technical disciplines. Also, U.S. aerospace firms are losing international business opportunities to foreign competitors who are just as advanced in some technologies. Steps should be taken to more systematically disseminate foreign technical literature to U.S. professionals. The current federal technology transfer policy diminishes the possibilities for cooperative aerospace agreements between U.S. and foreign governments, because the latter are reluctant to participate in arrangements which overly limit their access to certain technologies.

In a 1984 position paper, "Communicating Technical Information," the AIAA called for reducing to a minimum the items on the Militarily Critical Technologies List (MCTL) by creating disciplinary peer groups with the background and knowledge of the worldwide literature needed to judge which unclassified technologies are already sufficiently well-known to warrant removal from the MCTL. Although the MCTL has recently been reviewed in this context, the evolutionary nature of science technology requires frequent reevaluation of the list. Such reviews should, of course, reflect the overall security interests of the U.S. and its allies in denying access to classified technology.

## Commercialization

NASA is primarily an R&D agency and cannot itself engage in commercial activities. In a number of instances, such as satellite communications technology and meteorological satellites, NASA space R&D has been spun off to the private sector or to other user agencies.

By Presidential direction there is a current effort to increase the use of space and its technologies by the private sector. Two laws were enacted in 1984 – the Commercial Space Launch Act and the Land Remote Sensing Commercialization Act – followed by several other government actions. The Department of Transportation has set up an Office of Commercial Space Transportation; the White House has created an Interagency Commercial Space Working Group; and NASA has set up an Office of Commercial Programs to encourage

**FREE-WORLD GOVERNMENT CIVIL SPACE APPLICATIONS BUDGETS***
(APPROXIMATE: IN MILLIONS OF THEN-YEAR U.S. DOLLARS)

| ENTITY | SATELLITE COMMUNICATIONS | | REMOTE SENSING | | MATERIALS PROCESSING | |
|---|---|---|---|---|---|---|
| | 1983/84 | 1986 | 1983/84 | 1986 | 1983/84 | 1986 |
| European Space Agency | 222 | 249 | 41 | 198 | 75 | 39 |
| France | 52 | 105 | 92 | 120 | 8 | 14 |
| West Germany | 100 | 30 | 5 | 8 | 22 | 32 |
| Japan | 73 | 109 | 66 | 99 | 9 | 14 |
| Canada | 33 | 36 | 35 | 43 | N/A** | N/A |
| Total | 480 | 529 | 239 | 468 | 114 | 99 |
| Unites States | 32 | 100 | 15 | 24 | 22 | 35 |

*Data for U.K. and Italy unavailable.
**Not available.

commercial space activities. NASA has also moved to involve commercial firms more actively in Shuttle turnaround processing, space transportation, space-station design, development, and operations, and other major programs. NASA's Office of Commercial Programs has acted to increase aerospace and nonaerospace private-sector awareness of space opportunities and to encourage more industry investment and participation in space-based product R&D, employing Joint Endeavor Agreements (JEAs) and Technology Exchange Agreements (TEAs). The Office has also funded nine Centers for the Commercial Development of Space.

All these efforts have raised the interest level of potential investors, but have not yet inspired much actual investment. Most space activities involve high economic risk and long-term commitments of resources, which commercial organizations have been unwilling to undertake, even when incentives such as R&D and investment tax credits were still available. While communication satellite profitability can be assessed directly, many other proposed space commercialization activities are speculative and are perceived to have unacceptable risk for investment purposes.

NASA can make commercialization more attractive by increased efforts on high-technology space-based process and product R&D such as microgravity processing; by technical developments, particularly in civil remote sensing and communications; and by establishing a long-term, consistent pricing and operations policy for transportation, facilities, and other services.

But by far the most important element in meeting vigorous foreign competition in commercial space developments is a substantial increase in federal support for research and facilities. The accompanying chart shows the relative support for commercially related space activities currently being provided by foreign governments, as compared with U.S. efforts.

In remote sensing, if U.S. commercial systems derived from Landsat are to compete with the French SPOT and the Japanese ERS series, the government must honor its commitments in the transfer of Earth-observation functions to the private sector, as discussed earlier. Moreover, U.S. systems will need, among other enabling technologies, high-resolution multispectral sensors and ocean color instruments, particularly "push-broom" sensors (like SPOT's) using charge-coupled devices.

In communications, the Advanced Communications Technology Satellite (ACTS) demonstration program has been cited previously as an essential element in bringing U.S. capabilities up to levels beyond those already achieved by Japan in Ka-band (30/20 GHz) operations and baseband switching, and must continue to be pursued vigorously.

Space manufacturing and processing activities are thought to have high potential, particularly by European and Japanese interests. However, there are not yet sufficient data from NASA's low-level microgravity science and technology development program to interest many U.S. investors. Therefore NASA should continue to develop vigorously a more effective program to demonstrate the technical benefits of the space environment to potential users, and should coordinate the agency's microgravity science programs with the commercial programs office to ensure the practical direction of funded R&D programs. In addition, more flight opportunities than are currently available are required to conduct the needed research. The government must accept its role as the principal supporter of basic and applied research and commit the necessary resources, including reasonable support services, to provide microgravity research facilities.

NASA should continue to encourage private sector participation in space by the use of JEAs and TEAs, and the agency should also consider lease arrangements for privately-owned space assets to attract venture capital and reduce overall costs for new laboratory facilities needed to conduct research and commercial development activities. Further, the government must recognize the importance of its procurement policies to commercial space ventures, and move aggressively to implement administration promises to purchase products and services from the private sector.

## Space Station

The original goal of the space station program, as stated by President Reagan, was to have a permanently manned station in orbit by 1994 or sooner. Besides meeting the near-term objective of supporting advances in space science, technology, and commercialization, the station is a key element in the space infrastructure necessary to accomplish goals and objectives of the type suggested by the National Commission on Space. The continuing presence, since 1971, of manned Soviet stations in orbit, and particularly the stated Soviet intention to use the new Mir station to establish a large permanent facility and offer its facilities to western nations, must be considered in the context of U.S. plans.

The current U.S. space-station program is proposed as the next major step towards manned space utilization. A baseline design configuration has evolved which attempts to satisfy concurrently all user application needs; e.g., observation, materials processing, life sciences, technology, and servicing. That configuration, however, does not yet reflect changes in the U.S. launch fleet that will certainly take place when launch operations resume. Even with a fourth orbiter to replace Challenger, the new projected Shuttle flight rate may not be able to support timely assembly of the initial station, its projected logistics requirements, and crew safety considerations without seriously limiting space-station payload deployment or other NASA commitments. Further, it is possible that simultaneously fulfilling all the abovementioned user requirements, while at the same time seeking significant technology advancements, could increase cost beyond budget estimates.

The space station, then, could fall into the same trap as befell the Shuttle: near-term budget availability could become inconsistent with long-term low operational cost objectives. NASA recognized this situation in July 1986 and has reexamined the space station program plan to introduce the flexibility needed to accommodate these uncertainties.

Because the space station's low-Earth-orbit operational capability is essential to U.S. preeminence in space and to future space initiatives such as those proposed by the National Commission on Space, it should be budgeted to meet the scheduled 1994 deployment date. However, NASA's program plan must have sufficient flexibility to phase in transportation support, safe and practicable assembly, user accommodation, and advanced technology realistically in terms of both budget and schedule. The recent launch vehicle failures and the subsequent curtailment of U.S. launch capability clearly point out the need for alternate and redundant transportation modes to deploy and supply the station and provide emergency crew return. Hence the station design should be revisited to take advantage of the launch capabilities of both the Shuttle and expendable launch vehicles (U.S., European, and Japanese). NASA should continue to seek maximum practical use of advanced technologies, particularly automation and robotics, and to seek the interest of the private sector in any particular segments of the system that can be made attractive to commercial interests.

President Reagan has called for substantial foreign participation in the space station program, an inherently sound policy but one which introduces some degree of ambivalence. On the one hand, the growth of foreign technological and economic strength makes possible substantial contributions to the program that increase the capability of the system. On the other hand, as an investment of U.S. funds, the space station program must give highest priority to supporting the needs of the U.S. public and the private sector rather than those of its overseas partners.

NASA is currently negotiating agreements (1) with Europe, for their investment of up to $2 billion toward development of a pressurized laboratory called Columbus, a resource module, a free-flying polar-orbit platform, and a free-flying co-orbiting platform; (2) with Japan, to invest up to $1 billion for development of an experiment module with a remote manipulator arm and an attached logistics module; and (3) with Canada, to invest up to $500 million to develop a mobile remote manipulator system.

To achieve the positive benefits of cooperation, the international partners must be assured of a serious, long-term U.S. commitment to the program. They must also be treated as major shareholders who are participating in the program in pursuit of their own legitimate objectives. Past cooperative ventures, while overwhelmingly successful in general, have demonstrated U.S. inconsistencies and the pursuit of unilateral advantages inimical to cooperation. The International Solar Polar Mission is usually quoted as an example of the first, and the European investment of $800 million in Spacelab, for which they believe they received little in return, is perhaps the best example of the second. The space-station negotiations are accompanied, therefore, by a degree of suspicion that can only be assuaged by careful attention to the reasons for that suspicion. Congressional restrictions on foreign space-station activities, for example, have unnecessarily complicated the negotiations.

To avoid potential negative effects of cooperation, equal attention must be paid to three elements: (1) achievement of a satisfactory quid-pro-quo, (2) equitable arrangements for the distribution of operational costs, and (3) the active pursuit of a U.S. program to employ the space station infrastructure.

With respect to the first, the potentially conflicting objectives of the partners must be acknowledged. For example, the Europeans have made it clear that they expect their participation to lead eventually to autonomous European manned space capability, and the Japanese want both to enhance their own space development abilities and to apply space technologies in their Earth-based industries to make them more competitive. These are not reasons to avoid cooperation, only objectives that must be understood in the negotiation process. NASA must ensure that the U.S. participates fully in those elements of the space station that lead to long-term economic, scientific, and technological gain.

With respect to operational costs, and because NASA will provide the largest segment of the core infrastructure, consideration should be given to sharing the total operations cost on a use-based formula, rather than on a contributed subsystem-only basis or similar formulas that would not reflect the total burden. NASA's current efforts in this area are encouraged.

These steps are necessary, but assure only that costs are

equitably distributed. Benefits will be proportional to the vigor with which a nation employs the space station resource. If the U.S. investment in the program is not accompanied by a strong exploitation of the capability, the preceding precautions will be futile. The concerns that have been expressed by several members of Congress that NASA will "give away the store" in the space-station negotiations will then be real. But the best way for the U.S. to stay ahead of its foreign competitors, both in the space station and in other high-technology areas, is to move faster and more effectively than they do in research and technology development, not to bar their cooperative participation in developing new and potentially valuable space facilities.

## Education

The consequences of the space crisis of 1986 are already evident, primarily in the reassessment of past practices and systems. Perhaps the most important result of the crisis, however, is the opportunity it offers for renewed and vigorous attention to the motivation of the next generation – those who will manage and conduct the nation's space programs in the future.

The last major reform in science and engineering education in the U.S. occurred with the National Defense Education Act of 1958, in response to the challenge of Sputnik. Conditions have since deteriorated at all levels of the U.S. education system, from elementary to graduate school. Differing but related obstacles must be overcome at each level to correct the future potential shortage of qualified human resources needed to carry the space program into the next century.

At the elementary school level, many teachers are reluctant to incorporate science and technical subjects in their curricula, because they are neither prepared through proper background nor equipped with appropriate teaching materials to present such subjects adequately.

At the high school level, conditions have deteriorated to the point at which less than half of high school juniors and less than one third of seniors take a science course, according to the National Science Board's 1985 report on "Science Indicators." The consequences, according to recent surveys, are that an estimated 90% of U.S. high-school graduates are unable to undertake even routine high-technology tasks, and only 6% of U.S. high-school graduates are proficient in math and science as contrasted with 90% in Europe and Japan. A shortage of qualified science and math teachers, exacerbated by unattractive salaries and teaching conditions, is producing an even smaller pool of candidates for undergraduate university engineering programs. The undergraduate university science and engineering programs in the U.S. suffer from faculty limitations, both in number and in quality, and from curricula which in many cases have not adequately adapted to meet the changing needs of the professions they feed.

The graduate engineering education crisis is reflected in the decreasing fraction of U.S. students in aerospace-related graduate departments, where high-quality foreign students, many of whom return to their homelands, are often in the majority. The limitations of the faculty and the lack of adequate up-to-date laboratory and research facilities are major contributors. The attractiveness of entry-level salaries in industry has also contributed to the shortage of qualified undergraduates willing to make the commitment to full-time graduate school, according to the National Science Board.

Some of these concerns are reviewed in the report of the National Commission on Space, which concludes that the space program in general, and NASA in particular, could be a major influence in reshaping U.S. science and engineering education from elementary to postgraduate levels, as occurred after Sputnik. The five actions proposed by the Commission are that educational initiatives centered on the space program be used to motivate young people toward science and technology from elementary through high school, that Congress authorize a vigorous NASA graduate fellowship program, that funding be increased for university space research and technology programs administered by federal agencies, that NASA undertake a program to upgrade space research equipment, and that more frequent suborbital and orbital experiment opportunities be provided by NASA to university research programs.

Several additional programs could further address the specific issues at each level of the U.S. educational system. Recognizing that the influence of the space program at the elementary through high-school levels is to provide incentive and inspiration for future space-related careers, a central clearinghouse should be established for the dissemination of educational materials focusing on the space program. Private ventures such as the Young Astronauts Program and "Space Camps", as well as the "Teacher in Space" program and the Children's Challenger Center for Space Science (created by the families of the Challenger crew), should be supported to foster enthusiasm for the space program at the elementary and secondary-school levels.

The vitality of the future U.S. civil space program is inextricably tied to the improvement of both the quantity and quality of engineering graduates emerging each year from U.S. colleges and universities. New and innovative approaches to achieve such improvement should be emphasized, including expansion of "co-op" programs to the graduate level, establishment of Centers of Excellence at those universities with specific disciplinary strengths, development of curricula in astronautics and in space science, providing more summer employment opportunities for bright students at NASA centers and in industry, the temporary assignment or loan of senior industry engineers to teaching positions in major universities, attracting early-retirement engineers to the teaching profession, and having NASA technical personnel serve as grant monitors for university research.

Unless the youth of this nation are strongly motivated to seek their careers in the often difficult fields of science and technology – of which space is a particularly exciting and rewarding constituent – no amount of federal program emphasis can by itself sustain a long-term leadership role for the U.S. in civil space activities.

The American Institute of Aeronautics and Astronautics, the world's largest and oldest technical society in aeronautics and astronautics and related defense systems, was formed in 1963 by the merger of the American Rocket Society and the Institute of the Aerospace Sciences, which date back to 1930 and 1932, respectively. The Institute furthers the common good of aerospace by serving highly motivated engineers, scientists, managers, policymakers, and other aerospace professionals. Besides thousands of professionals doing research, design, and engineering development, AIAA's 40,000 members include group leaders, chief engineers, technical directors, government officials, and company officers. And the Institute cultivates 8,000 student members—tomorrow's aerospace practitioners and leaders—in 127 branches throughout the world.

Dr. LOGSDON Our basic conclusion is that a year after the *Challenger* accident, the U.S. civilian space program is still in crisis. Efforts to reconstitute the national space policy and to reshape NASA's programs and structures have not yet reflected a basic reality, our commitment to go into space to stay. We are planning to deploy long-term automated facilities and use them on a facility basis. We are proposing to go into space with humans on a permanent basis.

Year-by-year budgets are just not an adequate approach to this reality. What is required, AIAA believes, is a national commitment to investments in our future in space, and then the annual increments to honor that commitment in that investment.

We agree with Mr. Roe's recent testimony to the House Budget Committee regarding the need for a visionary national space policy and for a budget adequate to carry out a leadership program. Like Mr. Roe, we commend the Administration for requesting a significant increase in the Fiscal 1988 budget, but we share his belief that the budget request is, and I quote him, "woefully short of what is needed."

The public support for an increased NASA budget is there. A recent survey has shown a strong shift of sentiment in favor of the civilian space program, with 47 percent of those queried after the accident supporting an increase in NASA's budget. Over 50 percent of Americans think the United States—in fact, expect the United States—to try to land men and women on Mars within the next 25 years.

AIAA believes that a strong civilian space program is essential to national vitality and to success in our foreign relations. Other nations, not just the Soviet Union but those in Europe, Japan, China, recognize this and have made their own strong national commitments to space. Over the past two decades, we have not made and sustained a similar commitment.

Our current problems really are a direct result of two decades of inadequate investment and of attempting to do more than resources would support.

Our central message again is that if the United States decides to be a leading spacefaring nation and to commit itself to a plan and polices commensurate with those objectives, the civil space budget must be increased as rapidly as practical to an adequate level and then continue to grow, in our judgment, at a rate at least equal to that of the Gross National Product.

The budget policy of the last two decades will ensure that the United States becomes and remains a second-class power in space. If space preeminence is our national objective, we need to set goals with measurable milestones, commit the funding at a pace commensurate with the attainment of those goals.

Those that are responsible both in the White House and up here on the Hill for budget policy and decisions need to recognize NASA as an investment. An area such as space creates future capabilities, leads to economic growth, leads to increased government revenue, and essentially defines the kind of future world that we will live in.

That is our kind of general statement. Mr. Hieatt will address the specific comments on the 1988 budget.

Mr. HIEATT. Mr. Chairman, members of the committee, what I had planned to do is to just summarize what you have in writing very quickly and succinctly, and then you can ask questions. I think you will find that we have addressed all of the points that you brought up.

In the area of space transportation, it's our position that the Government has to give highest priority to reestablishing the U.S. launch capability, and to do that, we say you need to create a mixed fleet with shuttles and expendables; you need to return the space shuttle to flight status; and you need to produce and develop the research and development to try and reduce the cost of going into space.

The initial budget this year does not have anything for ELVs, and we recommend that it include funds to provide ELVs to NASA.

In the area of the Space Station, as we've testified in the past, we support the Space Station as a very important program. We believe that it should get on a schedule which will have a significant capability by 1994. In other words, we do not support a man-tended approach.

In the area of space science, the task force that we worked on came up with the conclusion that we should double the budget in the area of space science. We should do that in an appropriate period of time and in a way that goes along with the science community's recommendations.

There is, you know, obviously a reduction in space science this year in the budget, which we do not agree with.

We were very disappointed that NASA had proposed to delay the Mars Orbiter. Since the Mars Orbiter can go on a Titan booster, we strongly recommend that NASA go forward with that and get our space science program moving again.

We were very happy to see the Global Geospace Science mission initiated in the budget this year. As we testified last year, we would advocate an increase of funding in Explorer missions and in the development of instrument small payloads. An increase in the science budget would allow, you know, an expansion in that kind of a program.

In the area of space applications, we are very concerned, if we look at our expenditures versus those of our, you know, either allies or competitors abroad, they are spending more money in the area of space communications, materials processing, and remote sensing. And we do not agree with Fletcher's testimony that NASA should not be in the communications technology business. We feel that NASA should support those technologies which are so risky that industry cannot afford to go forward with them, and on that basis, we strongly recommend that ACTS be put back in the budget for this year.

In the area of materials processing, we feel that that area has, in fact, not been given proper emphasis over the years since it started and that more emphasis should be given to that.

We'd also like to recommend that NASA and DOD consider developing a policy where they could fly commercial kinds of missions on DOD shuttle missions where they've got room in the middeck.

In the area of space technology, we support the recommendations of the National Commission on Space to increase space technology by threefold. We were very happy to see the Civilian Space Technology Initiative, but we do believe that it still needs further increase in funding to get us back on track in the technology area.

That concludes the summary of the testimony, and obviously we're ready to answer questions.

[The prepared statement of Dr. Logsdon and Mr. Hieatt follows:]

Statement to

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
U.S. House of Representatives

by

Dr. John M. Logsdon
Vice-Chairman, Public Policy Committeee, AIAA

and

Mr. James L. Hieatt
Chairman
AIAA Technical Committee - Space Syatems

10 March 1987

American Institute of Aeronautics and Astronautics

Mr. Chairman, the American Institute of Aeronautics and Astronautics (AIAA) again thanks you for this opportunity to present its views as you consider the NASA budget for FY 1988.

AIAA is a non-profit professional society dedicated to advancing the art, science, and technology of aeronautics and astronautics and to nurturing and promoting the professionalism of those engaged in these pursuits. We have a membership of over 40,000 drawn from various levels of American industry, academia, and government as well as from numerous nations abroad.

Most of AIAA's testimony today will focus on the specifics of our assessment of the NASA FY 88 budget request. This assessment, however, is based on an extensive AIAA review of the nation's posture in space and of the requirements of U.S. leadership in civilian space activities that has been carried out during the past year. That review reflects the considered judgment of the nation's leading group of aerospace professionals; a copy will be provided to your committee as soon as possible, and we would like to request that it be included in the record.

We believe that, a year after the Challenger accident, the U.S. civilian space program is still in a crisis situation. Efforts to reconstitute national space policy and to reshape NASA's programs and structure have not yet reflected the realities of our commitment to go into space to stay. We are planning to deploy long-term automated facilities, such as the Hubble Space Telescope and other Great Observatories, and we are proposing a permanently manned space station as a necessary step

toward eventual human settlement of the Moon and Mars. Year-by-year budgets, adjusted at the margin to reflect decisions on specific programs, are just not an adequate approach to this reality. What is required is a national commitment to investments in our future in space, a government policy that identifies the goals and milestones to achieve that vision of the future, and then annual budgetary contributions to that space investment portfolio. AIAA agrees with Chairman Roe's recent statement to the House Budget Committee regarding the need for a visionary national space policy and for a budget adequate to carry out a leadership program in space. Like Mr. Roe, we commend the Administration for requesting a significant increase in NASA's FY 1988 budget, but we share his belief that that budget request is "woefully short of what is needed."

The public support for an increased NASA budget is there. Dr. John Miller of Northern Illinois University recently reported that, in the aftermath of the Challenger accident, there was a strong shift of sentiment in favor of the civilian space program, with a forty-seven percent increase in support of increased funding. Over fifty percent of Americans think that the United States should try to land men and women on Mars within the next twenty-five years. The challenge to the White House and to Congress is to provide the leadership to make that aspiration a reality.

A strong civil space program is essential to continued national vitality and successful foreign relations. Other nations--not only the Soviet Union but also those in Europe, Japan, and China--recognize this and have made strong

commitments to space. The United States over the past two decades did not make such a commitment, at least in terms of providing the budgetary resources required to support an across-the-board leadership program. Our current problems in reconstituting our civil space program are a direct result of two decades of inadequate investments and of attempting to do more than resources would support.

To repeat our central message, there is a fundamental inconsistency in attempting to achieve U.S. preeminence in space with budget policies under which civil space program funding declined sharply (in constant dollars) over the past two decades. If the U.S. elects to be a leading space-faring nation and to commit itself to a plan commensurate with that objective, the civil space budget must be increased as rapidly as practical to a level required to support such a plan and then continue to grow at a rate at least equal to that of the gross national product.

The budget policy of the past two decades will ensure that the U.S. becomes and remains a second-class power in space. If space pre-eminence is a national objective, the choice is not simply to select among fixed-budget alternatives, as has been done in the past, but to formulate an achievable set of national civil space goals with measurable milestone objectives, and then commit the funding needed to proceed at a pace commensurate with the attainment of those goals. It is particularly important that those responsible for government budget policy establish an appropriate level of investment in areas such as space, which creates future capabilities, leading to economic growth,

government revenue, and the ability to fund future government activities.

Space Transportation

Developing and operating space transportation systems has occupied over 50 percent of the NASA budget since 1960. Adequate transportation capability is essential to our ability to utilize and exploit space. It is AIAA's position that the government must give highest priority to re-establishing the United States launch capability 1) by creating a mixed fleet of Shuttles and expendable launch vehicles; 2) by returning the Space Shuttle to flight status, and 3) by reducing the cost of transportation to space. The approach to enhancing U.S. space transportation capability must involve both government and private commercial operations.

Recent space launch failures have forced reconsideration of America's space policy. At last summer's AIAA expendable launch vehicle workshop, requested by former Congressman Don Fuqua, there was unanimous agreement that the nation could no longer afford to depend upon a single launch system. As a result, the mixed fleet concept, including the STS and ELVs, has been extended to include the encouragement of commercial launch vehicle operations. Initial funds to allow NASA to procure adequate ELVs to carry out this strategy should be included in the FY 88 budget. We also recommend that the government move positively toward the achievement of low-cost launch capability, which will benefit the Space Station, NASA science programs and the commercial sector.

## Space Station

As we have testified before, a permanently manned space station is important to near-term scientific, technical and commercial progress. It also supports the pursuit of long-term goals such as those proposed by the National Commission on Space; hence, the program should proceed on schedule to meet the 1994 deployment date. However, NASA's program plan must have sufficient flexibility to phase in transportation support, user accommodation, and advanced technology realistically in terms of both budget and schedule. In that regard, it is desirable to consider space station approaches which: accommodate the use of ELVs in addition to the Shuttle for deployment, resupply, and operations (including compatibility with European and Japanese vehicles), provide for emergency crew return, and are compatible with attaining significant initial operating capability in 1994. NASA should continue to seek maximum practical use of automation and robotics in the station design and to encourage both U.S. private sector and foreign participation in developing and operating the station.

## Space Science and Applications

The AIAA Space Task Force has called for a doubling of the space science budget over an appropriate period of time in accordance with the recommendations of the science community. The FY 88 budget proposes a $34 million reduction from FY 87.

After 30 years of impressive accomplishment, U.S. space scientists are now experiencing a traumatic disruption in their access to space. The NASA Space and Earth Sciences Advisory

Committee (SESAC) in its recent report has identified our present situation as a crisis. We concur with this evaluation, and with the remedies proposed by SESAC. In particular, as noted earlier, we agree that NASA should follow a mixed fleet strategy.

The AIAA views with considerable dismay the proposed further delay of the Mars Observer. When originally approved, this proposed program was to be a quickly-executed, low-cost, very worthwhile planetary science mission, one that would be an integral element of the strategy developed by the Solar System Exploration Committee. The program was designed to require only three years from start to launch in 1988 and to cost about $165 million. The launch has already been delayed two years to 1990. This has resulted in a substantial cost increase. It is now possible that the launch will be further delayed until 1992 in order to reflect the priorities embodied in the current Shuttle launch schedule. This will further increase the cost and reduce the possibility of meaningful collaboration with the Soviets' Mars exploration. The Mars Observer can be launched by the Titan III booster. If NASA really wishes to move to a mixed fleet approach and to get the space science program moving forward again, a Titan III launch for Mars Observer would be a major step in that direction.

We applaud the proposed new start for the Global Geospace Science (GGS) mission as the principal U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. This comprehensive study of the physcial interactions in the Sun-Earth system by two NASA, one Japanese, and five ESA spacecraft has

been ranked by the space science community as the highest priority program for studing the Sun's effect upon the terrestrial environment.

We are also pleased that NASA will respond to the opportunity for a new cooperative mission with the Japanese. NASA will supply a soft X-Ray telescope for the Japanese Solar-A spacecraft, which will be launched in 1991 to study the sun at the next solar maximum.

The increased budgets for the research, data analysis, and suborbital (rockets and balloon) program, while typically modest, will do much to maintain the vitality of the basic research disciplines during the current crisis.

NASA is commended for its continued support of major flight programs now under development such as TOPEX, HST, GRO, UARS, and others.

As we testified last year, the AIAA advocates an increase in the funding of the Explorer Missions and funding for the development of instruments for small payloads as experiments-of-opportunity on spacecraft launched by the DOD, NOAA, or foreign programs (as for example, SOLAR-A). An increase in the overall science budget would permit support for these high-payoff, relatively low-cost areas.

AIAA feels strongly that it is in the best interest of the U.S. to participate in joint planetary exploration missions with other space-faring nations in the 1990s. In particular, we recommend consideration of coordinated U.S./Soviet Mars exploration, beginning with orbiters, progressing to unmanned rover and sample return missions and culminating in a joint

manned Mars mission. Such a program, in addition to its value for science and exploration, will begin a long-term dialogue with the Soviets and could substantially enhance mutual understanding.

Mission operations and data analysis for several spacecraft are not adequately funded. In the absence of new flight opportunities, it is essential that NASA continue to operate spacecraft that are still returning scientifically useful data and that mission investigators receive adequate funding for analysis of that data. Sufficient flexibility in the mission budget to allow for taking advantage of unique opportunities such as the current supernova is highly desirable.

## Space Applications

Space leadership and its economic benefits to the nation are both at stake in commercial space activities. Strong foreign intiatives in space processing, satellite communications, and remote sensing are not being adequately matched by U.S. programs, primarily because of inadequate support for technology advancement and research facilities.

NASA's role in communications satellite research and development should be to provide a solid technology base that will bring the risks of developing advanced communications satellites into an acceptable range for U.S. industry. We believe that adequate progress on these generic research and technology development programs will require an FY 88 funding level signficantly higher than the current $14.4 million NASA budget estimate for communications research and analysis.

In light of the above, and given the substantial investment to date in the Advanced Communications Technology Satellite (ACTS) program, we strongly recommend that ACTS be reinstated in the NASA budget and the program brought efficently to completion.

For the past several years the AIAA has advocated a substantially increased effort in the area of commercial use of space. We feel that present plans and policies are inadequate for materials processing in space and the commercial use of related space facilities. The impact of the Challenger accident has been to severely limit regular access to space by the private sector, and commercial uses of space have been given low priority in NASA's recovery plan. As one way of providing increased access, we recommend that NASA and DOD consider developing a coordinated plan for accommodating commercial payloads DOD flights.

## Space Technology

AIAA supports the recommendation of the National Commission on Space for a three-fold increase in funding for space technology advancement. AIAA applauds the proposed Civilian Space Technology Initiative. A re-emphasis, with increased budgetary support, on technology development is a most desirable step in the direction of continued United States leadership in space. However, we agree with NCOS that an even greater commitment of resources is needed. We also urge increased commitment of funds for key technologies such as propulsion, automation and robotics, flight computers, information systems, sensors, power generation, materials, structures, and life support systems.

For booster application, the development of advanced, high pressure Liquid Oxygen/Hydro-carbon engines and turbo pumps, as well as in-flight diagnostics, are essential near-term objectives. With respect to the National Aerospace Plane, it is essential that studies and experimental efforts be unified to define the performance characteristics of combined rocket and air-breathing engines for single-stage and two-stage launch concepts. Further advances in materials research and alternative rocket fuels, such as slush liquid hydrogen and triple point propane, offer major longer-range payoffs. All aspects of space propulsion, including more futuristic concepts, should be investigated.

That concludes my remarks, Mr.Chairman. We will be happy to answer any questions you may have.

Mr. NELSON. Okay. We happen to agree with almost everything that you've said. Before we get into questions, we have a recorded vote on the floor right now, so I'm going to recess the committee. There are two votes. It's a live-and-five, and we've got—or rather you've got one 15-minute vote followed by a 5-minute vote, so there are two.

Right after this, we'll be back, and we'll resume the committee. Thank you.

[Brief recess.]

Mr. NELSON. We would ask the rest of our panel to come on up, and if you need some more chairs, just pull them up.

Okay. We will start with the IEEE, and I guess we really should have started with all of you at the table, but we just sort of went ahead, with Mr. Hieatt and Dr. Logsdon.

So Dr. Flajser, why don't we hear from you, and we'll just proceed on.

**STATEMENTS OF DR. STEVEN H. FLAJSER, CHAIRMAN, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, WASHINGTON, DC, ACCOMPANIED BY TERRY HART, VICE CHAIRMAN, AEROSPACE RESEARCH AND DEVELOPMENT COMMITTEE, IEEE.**

Dr. FLAJSER. Thank you, Mr. Chairman.

It's an honor for us to be here again this year, and I'll summarize the testimony, as you wish. I'm accompanied by Terry Hart, who is Vice Chairman of the Aerospace R&D Committee, and now has graciously agreed to answer all the hard questions you may have for us.

Mr. NELSON. We are delighted to have a movie star with us—Terry Hart, the movie star in "The Dream is Alive," showing nightly—showing daily at the Air and Space.

Dr. FLAJSER. Well, you just summarized our testimony for us. [Laughter.]

We hope, in fact, that's a reality.

We're encouraged by a couple of things that have happened in the last year, and the 100th Congress. There is now a House Science, Space, and Technology Committee. We can't help but notice the change in the title and hope that emphasis finds its way through other members of the Congress.

I will not describe for you the IEEE. I think you're familiar with the organization. It's an international organization in excess of a quarter of a million people, just under 200,000 in the United States.

Last year when we were here, it was about a month after the *Challenger* accident, and obviously everyone's attention was focused on that tragedy and the steps needed to recover from it. One thing that I think is fair to say, is that we're particularly encouraged because of the leadership shown by the Congress in putting into the budget funds to purchase an additional Shuttle orbiter. We testified then that that was a critical step. We also hoped that that funding would come not at the expense of other NASA programs, and we are pleased to see that it was a one-time, upfront funding.

During the past year, IEEE has, as you heard AIAA comment, reviewed our policy and position with regard to the civilian space

program, and appended to the testimony today is a new position statement that we generated with regard to the civilian space program.

As you will see, there is one message, really, that we would hope to impart here, and that is the emphasis on the need for essentially a national declaration of goals for the space program. We feel they are lacking. We feel they were called for in the 1958 Act, specifically, leadership in space once again. If you will, "the dream is alive."

This year, as I think everyone realizes, we will be marking the 30th anniversary of a space endeavor that did not occur here in the United States, but started with the Soviet Union and the launch of Sputnik. And in looking back at that, it's clear that since that point where we essentially started behind, we caught up and really gained a leadership position in space, largely because of a similar declaration back in 1961 by President Kennedy.

We find that the Apollo era produced tremendous benefits for the United States. You know many of them here, and the committee has looked at them. We're not here to talk about them so much, but we want to emphasize a couple of things.

First of all, that really took leadership. It took commitment and vision that has been lacking the last few years.

The second thing is that as the benefits unfolded and we realized some of the benefits here in the United States, the international community certainly was listening and observing all the benefits the space program provided for the United States. And, over the period of the last couple of decades, they, too, have gotten into the space arena, first to be participants, and now in many cases leaders in various endeavors in space.

The third thing we observe is that much of the technology and the benefits of the Apollo era were a result of some of the investments in technology at that point. We basically concluded that we've used up most of the seed corn of that era.

Our basic position is that whether the term is "competitiveness, leadership, preeminence," this Nation needs to assume that leadership position once again. We've lost it in a number of areas, and we propose, as you will see in the statement, a number of goals, suggested goals for your consideration.

With regard to specifics, first of all, as we did last year, we continue to support the need for a fourth shuttle orbiter. I understand that there are some people revisiting the question of the need for a fourth orbiter, and we continue to endorse that.

Second, we continue to endorse the development of a Space Station. I would like to quote—I'd like to read specifically the words in our statement:

> We support establishing a permanent presence in space, an essential step towards reinvigorating the U.S. civilian space program; however, given the severe budget deficit facing the Federal Government, the rationale and consequences behind the funding of an expensive enterprise such as the Space Station must be fully understood. We must establish definitive objectives for a balanced space program, civilian space program, within which Space Station would be just one element.

We essentially take the position that the nation needs a balanced space program, and it needs a balanced space program within the context of specific goals.

We support this balanced program and feel that a Space Station development without an adequate and robust science and applications program is not in our national interest. We also realize, however, that without a Space station, many of the activities of the space science community, the applications community, that the planetary community might be interested in, they couldn't realize some of those objectives.

We also observe that balance vis-a-vis the space program is important in two other areas. One is that if the United States were not to proceed with a civilian Space Station, the United States, particularly NASA, would fall even further behind a lot of the programs and technological activity that is occurring in the defense arena. As a result many of the smart, young, and talented individuals would be attracted to the defense space and aerospace activities rather than the civilian side, and that really would not be, we believe, in the national interest.

We do not question whatsoever the importance of the national security aspects of space. We're just making a point that you need to keep the civilian side robust as well.

The second observation with regard to balance is the balance between the United States and the Soviet programs. That started 30 years ago, and we think if the United States backed off a commitment to a Space Station development, we will find the international community gravitating more and more to cooperation with the Soviets, at our expense. They would depend on them for research; they would depend on them for technology development. And what we would find is that absent a U.S. commercial activity to develop a space program, absent a Defense Department initiative to build a Space Station, NASA really has to step in and fill that role.

We would suggest that hopefully this would not occur, but it would be very difficult for the United States public to fully understand why it is we would have to rent space from the Soviet Union to do research in their Space Station.

Turning to specifics of the budget, we tried to tie the NASA program to some of the half a dozen or seven goals that we articulated, the first one being the applications program.

We would encourage this subcommittee and the Congress to put the A back into OSSA. You hear a great deal about the aeronautics portion of the NASA. We would suggest that over the years, the applications programs in NASA have suffered a great deal, and the best example of this really is the ACTS program, where once again, this is the fourth year in a row that IEEE has endorsed the need to fully fund the ACTS program.

If there ever is a symbol of the need for competitive advantage, it is in the satellite communications area. We've talked about this now for the fourth year. We hope that the committee will restore the funding that's required and necessary to keep that program on schedule.

We also observe that there are other, sometimes overlooked communications activities in the NASA area that have proven very successful, not just from an economic point of view, from also other points of view. The search-and-rescue programs of NASA have saved almost 700 lives. This is an international endeavor with the

U.S. clearly involved, and also the mobile communications activities.

We feel that there are many more opportunities down the road in the communications area. There is a report that I understand is nearing completion coming from the Space Applications Advisory Council dealing with the future of communications R&D, and we look forward to that report, because I think they have some useful things to say in terms of long-range goals.

In fact, there are a number of other reports coming out of SAAC—I should back off and not use acronyms; I apologize—there are other reports coming out of that advisory group dealing with remote sensing, materials processing, information processing, that hopefully will serve in the applications area to set some guideposts for the future, as did the planetary program when the Solar System Exploration Committee issued its report.

One other point with regard to the applications program is, we note with dismay the possible demise of the LANDSAT system. That is not a NASA budget item per se at this point, but it is of tremendous importance to the scientific community and the research community in terms of where they're going to get some of the data.

Now that hopefully we've convinced you to put the A back in OSSA, in turn, we hope that you'll put the S back in as well. I think you've heard a great deal about the importance of some of the science programs in NASA, that they clearly are one of the most damaged participants in the space program as a result of the *Challenger* accident. They have lost a lot of flight opportunities. Many of their missions have been postponed, particularly true in the planetary area.

You alluded earlier to the need for ELV's for certain missions. I think one obvious example is to keep the Mars Observer on a 1900 launch, rather than 1992 launch.

It is sad for a technical person to look at what's happened in the science area and almost realize that in one professional lifetime, you may just have one mission to hang your professional hat on. The last planetary launch was in 1978, and the next one, I believe, will be no earlier than 1990. That is not going to attract talented people in the future if they can't do experiments.

I'd like to skip over one issue that often is discussed in the scientific community, whether it's space, energy, physics or whatever, the question of big versus small science. We conclude, in an ideal world, that we would like to have both. There's an importance in having some of the great observatories, such as the space telescope—there's also an extremely valuable contribution that small science, smaller space missions, can provide. To the extent that one can, it would be important to try to look at the expected scientific return per dollar invested.

The third goal deals with launch vehicles, access to space. As previously mentioned by AIAA and yourself, Mr. Chairman, we support a mixed fleet. We think there's actually nothing that is more important than trying to get the cost of getting to space down, but even before we do that, we just have to get to space at almost any cost, and that involves the purchase of additional ELV's.

The fourth area deals with commercial opportunities in space. Here we highlight two areas. One is materials processing; the second is the Office of Commercial Programs. Second to communications satellites, there's nothing perhaps in our future that is more important from a commercial point of view than some of the benefits coming out of the materials processing area. They are, however, severely limited in two regards. One is flight opportunities, and the second is budget, both of which hopefully will get augmented in terms of this budget.

The Office of Commercial Programs, there's some old and some new. The old that you're familiar with, the technology utilization efforts, the spinoffs, are very important. The committee in the past has been very supportive of that program, and we encourage you to continue to support it.

Likewise, the relatively new initiatives to develop joint centers, academic and industry Centers of Excellence, whether they be in materials processing or robotics. I think that's a very valuable effort in the commercial area, and we ask you to support that as well.

If we are to one day go back to the moon or possibly Mars through possibly manned missions, one of the areas that is going to be absolutely critical is our understanding of the human health effects of long duration in space, low gravity and high radiation environments. The life sciences budget, in that event, would have to be significantly increased. There, again, that's one area where the United States is taking a backseat to efforts by the Soviet Union.

The sixth goal involves the academic, the university base. There, this year, we basically support the somewhat modest but critical effort called the Vitality Package. Keep those university teams together, the graduate students, the professors, doing useful research, then they can get back into more active efforts when flight opportunities resume.

The seventh area in terms of goals involves the advanced technology, long-term goals. We support the new initiative called Civilian Space Technology Initiative. It's a multi-year program covering a number of technology areas, and there's an augmentation on the order of $70 million proposed by the Administration.

That's the seed corn for the future. No matter what directions and what goals one would want to pursue, the technology base needs to be invigorated.

We talked about several NASA programs. We talked about our motivation as one to try to seek leadership in space once again. We recognize finally, however, that leadership sometimes involves cooperation, particularly international cooperation. There are many areas of joint endeavors that are in our national interest, as well as of international interest. We support those and particularly support efforts to proceed with the International Space Year in 1992, and over the next months and years, IEEE will be proposing some initiatives in that area.

That concludes our testimony, and whenever you wish we'd be prepared to respond to some questions.

[The prepared statement of Dr. Flajser follows:]

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Testimony of Dr. Steven Flajser, Chairman,
and Mr. Terry Hart, Vice Chairman,
of the IEEE Aerospace Research and Development Committee
before the
Subcommittee on Space Science and Applications
House Science, Space and Technology Committee
March 10, 1987

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Mr. Chairman, and Members of the Subcommittee, the IEEE is honored to be invited again this year to provide its views on the NASA budget request. We are particularly pleased to appear realizing that the full Committee has changed its name to Science, Space and Technology. The added emphasis of Space in the title is a further recognition of the importance of Space to our Science and Technology base, and to our national goals.

The IEEE is the world's largest technical professional society with over 282,000 members in 157 countries. In the United States, there are more than 228,000 members, working in industry, Government and academia. Our members are active in a wide range of technologies that are important to the space program and to U.S. industrial competitiveness. We therefore have a special interest in the future of the U.S. space program and the role that this program plays in fostering the technological advances that will continue to fuel the high technology needs of our national industrial enterprise. Our views represent an amalgam of perspectives, many of which are not necessarily allied just with NASA or its program.

Last year when we testified before this Subcommittee, it was less than one month after the Challenger accident. Much of our attention was focused on the needed steps to recover from the accident. It is encouraging to us how much has happened to get the U.S. space program (civilian and defense) back on track. We commend in particular steps taken by the Congress to purchase an additional shuttle orbiter, and to do so up front, without having to take the money from other, already-impacted NASA programs.

In the course of the past year, the IEEE has reviewed its own policy position regarding the U.S. Civilian Space program and through our U.S. Activities Board developed a new position statement. The position statement is appended to this testimony. The statement emphasizes the need for a national declaration of goals for the U.S. space program that will help ensure regaining our leadership position--a primary goal of the Space Act of 1958.

Our testimony last year on the NASA budget was guided by our comments before the Paine Commission where we articulated some longer range goals. This year, our testimony on NASA's FY'88 budget is guided by the shorter-term goals (on the order of a decade) listed in our position statement. We find it advantageous to view annual budget requests in the context of certain guideposts.

The year 1987 marks the 30th anniversary of the Soviet Union's launch of Sputnik. That event shocked this nation out of a post-World War II complacency. Each night, the sky above served to remind us we were behind. In response, our nation mobilized. With political leadership and vision, and the sustained application of human talent and money we were able to overtake Soviet accomplishments and attain world leadership in space.

That leadership was attained largely by the 1961 decision by President Kennedy to set as a national objective the manned landing on and safe return from the moon within the decade. With a continuity of support by Congress and

three administrations, that objective was achieved. In so doing, we as a nation obtained huge benefits, social and economic, and in addition, achieved major technological advances.

Highlighting those benefits is not the purpose of this testimony. Rather, we wish to underscore three points. First, to achieve the leadership position in space it took vision, leadership and a commitment to meeting declared national objectives. Second, the benefits that came from the U.S. endeavor were readily demonstrated to others in the international community. They, in turn, realized the need to participate and eventually compete in this arena. In addition to that from the Soviet Union, competition in space today is both broad and deep. Third, even before the Challenger accident our competitive edge was threatened. We had already used up much of the seed corn of the Apollo era. While others invested, the shrinking budgetary support for the U.S. space program did not permit a replenishment of our domestic capability in a balanced fashion.

The IEEE strongly supports maintaining, and in some areas regaining, the U.S. competitive edge in space. To achieve this, we will need to reinvigorate our government, industrial and academic bases. With a declaration of national goals in space and the allocation of sufficient resources for a balanced program, we can do so. With a clear sense of national objectives, various NASA programs and projects would take on greater meaning.

We continue to support the need for purchasing a fourth shuttle orbiter as an essential element of our national capability.

We also continue to support the development of a space station. Quoting from our statement:

> Establishing a permanent presence in space is an essential step toward reinvigorating the United States civilian space

> program. However, given the severe budget deficit facing the Federal Government, the rationale and consequences behind funding an expensive enterprise such as a space station must be fully understood. We must establish definitive objectives for a balanced United States civilian space program, within which a space station would be one element.

This was drafted even before recent information on cost growth.

To build a space station, one needs to have a set of goals within which it serves as a means, not an end in itself. With an understanding of what our overall space objectives are we can determine better what appropriate design, schedule and cost profiles would be for a space station development.

In addition to goals there is the matter of balance. To have a space station without a healthy space science and applications program would not constitute the balanced program we propose as necessary to our national interest. On the other hand, without a space station, we could not achieve some of the longer range goals for space science, exploration and applications.

The question of balance is important in considering a space station development from two additional perspectives. Without a space station, the U.S. civilian space program would fall even further behind in technological activity and budgetary resources compared to defense space efforts. NASA, long attuned to keeping its vigor through major technological challenges, would atrophy further. The youth and the science and engineering talent of the nation would be attracted even more so to Defense Department aerospace programs. Nevertheless, we do not question the importance of our national security objectives in space; the issue is one of maintaining the vitality of the civilian side through new programs.

The other consideration involving balance deals with the relationship of the U.S. and Soviet space programs. If we were not to pursue a permanent presence in space--a capability the Soviet Union already has well in hand--our standing

in the international community would continue to erode. For example, the absence of a U.S. station would drive other nations closer to the Soviet Union for the purpose of using their station, collaborating with them on research and growing to depend on their technology more than ours. Without the likelihood of a U.S. commercial space station or one built by the Defense Department, NASA must take the lead. The U.S. public would likely find it difficult to accept the possibility of the U.S. having to rent space on a Soviet space station.

Mr. Chairman, the IEEE position statement provides seven goals which we will use in commenting on other NASA budget items.

1. Applications for Public and Commercial Purposes

We encourage Congress to help put the "A" back in NASA's OSSA (Office of Space Science and Applications) programs. Before we discuss the importance of the "S" of OSSA, we observe that applications programs suffer in their ability to gather NASA and OMB budgetary support. This is most evident in the inability of the Advanced Communications Technology Satellite (ACTS) program, again, to survive the Administration's budget process.

For the fourth year in a row, IEEE strongly endorses reinstituting funds for ACTS, a program that will help keep U.S. leadership in satellite communications. Satellites, because of their unique technical and market features, will continue to be used for telecommunications purposes, even with fiber optics technology. Whether in the future these satellites and associated ground systems are U.S. or foreign, depends largely on whether ACTS continues. U.S. industry will commercialize the technology after the proof-of-concept work, not at the R&D system stage. We hope Congress will provide the necessary $75M for FY 1988.

NASA has other communications programs worthy of support involving

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search and rescue and mobile communications. Additional future communications R&D efforts need to be proposed and developed. A long range plan and strategy in this area would be most welcome. We look forward to an upcoming report by the NASA Space Applications Advisory Council (SAAC) in this regard.

In fact, the SAAC has undertaken an effort to respond to a Congressional mandate to develop a strategic plan for NASA's entire applications program. The communications report is the first product; others, dealing with remote sensing, information systems and materials processing are in different stages of preparation. We hope these reports will serve the useful function that the Solar System Exploration Committee report did for the planetary program.

Another example of the need to focus on NASA's applications programs is remote sensing. NASA has relatively strong efforts underway in atmospheric and ocean remote sensing. However, the possible demise of the commercial U.S. Landsat system could seriously affect NASA's research efforts in this area. Questions arise regarding where U.S. researchers will get their data and what role NASA should play in technology development (e.g. sensors).

2. Science missions

One of the clearest losers from the challenger accident has been NASA's Space Science program. Of the 50 science missions that were to fly on the shuttle in these six years, (1986-1992), only 17 are scheduled to fly in the six year period once the shuttle resumes flight. Flight opportunities for science missions on shuttle and expendables need to be increased.

More science missions need to be approved. The existing delays due to shuttle coupled with the lean budgets of previous years have led to a

situation where some researchers now feel fortunate if they have one mission opportunity in their professional lifetimes. This situation has been particularly severe in the planetary area. The OSSA budget has been flat for science programs at a time when another Federal science agency apparently has been able to obtain a commitment from OMB to double its budget in five years.

One issue that often confronts the scientific community whether in physics, energy, space, etc., is the question of big vs. small science. For example, in the space arena it is put in terms of the great observatories vs. smaller missions. The issue of where the greater benefit lies is rarely resolved within the science community because some scientific knowledge can only be obtained through new, large scale, technology developments (e.g. the space telescope). On the other hand, for equal cost one can obtain a great deal of science through multiple, smaller missions. We believe NASA should continue to fund both approaches, with the objective in either case of the most expected scientific return per dollar invested.

3. Diversity of Launch Vehicles

The IEEE supports the development in the U.S. of a mixed fleet of launch vehicles. Where science missions cannot be manifested on the shuttle, an ELV should be procured. Where the availability of an ELV could make the launch date of a mission earlier, such as the Mars Observer (from 1992 to 1990), the earlier launch opportunity should be pursued. This all presumes that there is a diversity of transportation available. While this is not the case in the short term, over the next several years the combined efforts of the Air Force, NASA and the commercial sector should hopefully produce such a diversity.

The IEEE also strongly supports efforts by NASA and others to reduce sharply the costs of getting into space. We support the National Aerospace Plane and NASA's advanced technology programs aimed at cutting the cost to orbit. Nothing will affect the utilization of space more than driving these costs down.

4. Commercial Opportunities in Space

The IEEE supports NASA's request for materials processing and the Office of Commercial Programs. Research in materials processing is both budget and flight-limited. While we cannot predict where the materials research breakthroughs will come that will lead to social, commercial or national security benefits, we can be certain of two things. Without doing the research and flying experiments, breakthroughs won't occur. Secondly, if there ever is a place where the U.S. competitive edge needs to be ensured, it is here.

NASA's commercial programs are a mixture of old and new. The old includes the highly successful technology utilization efforts which look toward commercial and public spinoffs of technology developed for the space program. The new includes joint industry - university research Centers of Excellence. These centers work in areas, such as materials processing, which show some promise of commercial applications. The relatively new also includes joint endeavor agreements and technical exchange agreements between NASA and industry. We encourage the Subcommittee to support these and other efforts NASA might pursue to nuture private sector investments in space.

5. Exploration of the Solar System

Mr. Chairman, we've already mentioned the severe short fall in the planetary program's budget. If one day, the U.S. decides once again to

go to the moon and beyond with manned missions--which IEEE recommends that we do--then we will need to know a great deal more than we do now about human health and survival in a low gravity, high radiation environment. We support an augmentation of the life sciences budget with that goal in mind.

6. University Facilities in Space

Over the longer term, providing research facilities and opportunities for university scientists should be a national objective. However, in the short-term, without flight opportunities, keeping our research base together on earth is critical. We support the modest but important "vitality package" NASA is proposing in the FY'88 budget.

7. Advanced Technology and Longer Term Goals

One of the most important new initiatives in NASA's FY'88 Budget request is the Civilian Space Technology Initiative (CSTI). Space research and technology funding today is about one-quarter of what it was in the 1960s. We are living off the investments of the past and could not readily undertake new initiatives without replenishing the seed corn.

CSTI will focus on a number of areas. Efforts to lower the cost to space will depend on advances in propulsion and booster technology. Higher in-space power requirements in orbit will depend on new technology developments. Likewise, important automation and robotics developments will be targeted by the CSTI programs.

We support this multiyear program and the $70M increase for FY'88. The IEEE also supports an augmentation in the Advanced Programs area which contributes to development of long term goals in the areas of transportation and planetary exploration.

Mr. Chairman, we've commented on several NASA programs and more importantly on the need to have a declaration of national goals for space. In our appended policy statement we suggest some goals. We are encouraged by efforts within NASA to produce a set of shorter-term goals to bridge the period of longer term goals set forth by the Paine Commission.

In recommending a declaration of goals, IEEE has been motivated by the need to restore U.S. leadership in space and to regain the competitive edge. Leadership also implies that international cooperation is an important objective. The IEEE finds examples of many international joint ventures, particularly in science, that are in our national and international interest. We support joint ventures and the goals of the International Space Year (ISY) which Congress initiated, scheduled for 1992. As an organization we are working toward making a contribution to this important project.

To summarize, IEEE's view of the NASA budget is that it deserves the Subcommittee's support. We had previously written to Budget Director James Miller encouraging him to support a figure closer to $10B as necessary to help restore a balanced and competitive civilian space program.

The civilian space program led by NASA will generate valuable public and commercial services, increase scientific knowledge and advance our national technology base. We can ill afford not to make the nationally critical investments in our space program during these competitive times.

Thank you for this opportunity to present IEEE's views on the FY 1988 NASA budget.

Dr. Steven H. Flajser

Dr. Steven Flajser is Director, Space/Telecommunications Government Affairs for Fairchild Industries. He has been with the company since March, 1984. From 1975-1984, Dr. Flajser served on the staff of the Senate Committee on Commerce, Science and Transportation, most recently as Minority Staff Director of the Science, Technology and Space Subcommittee. His main responsibilities included the U.S. space program, national science and technology initiatives and programs to stimulate industrial technology development. Prior to that, he was on the faculty of the University of Washington in their technology Management program.

Born December 5, 1943, Dr. Flajser received his Bachelor of Science degree from the University of California, Berkley, and a PhD in Chemistry from the University of Washington.

Mr. Terry J. Hart

Mr. Terry J. Hart is a project manager for design of data processing systems for government applications at AT&T Bell Laboratories. He has been in this position since 1984. Mr. Hart began his career with Bell Laboratories in 1968, shortly after which he began active duty with the Air Force and the 108th Tactical Fighter Wing of the New Jersey Air National Guard.

In 1978, Mr. Hart was selected by NASA as one of 35 Astronaut candidates. This selection led to his being a member of the 11th flight of the Space Shuttle which lifted off on Arpil 6, 1984, when he was responsible for rendezvous navigation and targeting, the Remote Manipulator System (RMS) operation, and the IMAX camera operation.

Mr. Hart received a Bachelor of Science degree in Mechnical Engineering from Lehigh University in 1968, a Master of Science degree in Mechanical Engineering from the Massachusetts Institute of Technology in 1969, and a Master of Science degree in Electrical Engineering from Rutgers University in 1978.

# ENTITY POSITION STATEMENT

THE UNITED STATES CIVILIAN SPACE PROGRAM

The Institute of Electrical and Electronics Engineers, Inc.

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## SUMMARY

In its almost thirty year history the United States Civilian Space Program has placed requirements upon our technology which have resulted in major advances in computers, communications, guidance and control, and remote sensing. In more recent years, other nations have been excelling in technological endeavors which challenge the United States standing in Space Science and Technology. The IEEE United States Activities Board urges the declaration of a set of national goals for our space program which will ensure regaining United States leadership in space, a primary goal of the Space Act in 1958. This Position Statement presents such a set of national goals which, with appropriate budgetary support, should ensure United States leadership in space.

Approved: United States Activities Board — 02/18/87

Entity — Date

In its almost thirty year history, the United States civilian space program has led to a significant improvement in our understanding of the universe and our own planet. It has provided the means for global communications, remote sensing, and information processing networks. In doing so, its mission needs have created requirements in electronics reliability, miniaturization, weight, cost and versatility surpassing all previous performance standards. Accordingly, the United States space program has been, and continues to be, a critical driver of science and technology.

To meet the space program's needs, major advances have been made in numerous fields of electrotechnology, including computers, communications, guidance and control, and remote sensing. These technological advances have become the foundation for major new high-technology industries which contribute substantially to our nation's economy and balance of trade, and provide a major source of employment for our nation's workforce.

In recent years, the United States has been faced with intense economic competition from abroad. Increasingly, other nations are excelling in technological endeavors which challenge the traditional leadership role of the United States. Space science, exploration and commercialization are not exceptions. The IEEE is concerned that the United States' standing in space science and technology is declining. To reverse this trend, we must recapture the vision and leadership that will enable the commitment of national resources that was exemplified by the Apollo program.

In 1961 President Kennedy announced a definitive objective of the United States space program: the manned landing on and safe return from the moon before the end of the decade. At the time, it was not evident that this objective was possible, nor that any single nation possessed the necessary resources for its fulfillment. With the proper vision, leadership and continuity of national commitment through three consecutive Administrations, the Apollo Program accomplished President Kennedy's objective on July 20, 1969.

The United States is now again on the threshold of a significant new space venture, the space station, which will provide a permanent manned presence in space for research and applications. Establishing a permanent presence in space is an essential step toward reinvigorating the United States civilian space program. However, given the severe budget deficit facing the Federal Government, the rationale and consequences behind funding an expensive enterprise such as a space station must be fully understood. We must establish definitive objectives for a balanced United States civilian space program, within which a space station would be one element. We then must provide the continuity of national commitment that will be required if we are to exploit fully such an effort for our competitive advantage.

A new national consensus on the United States goals in space is necessary. While the National Space Strategy, as approved by President Reagan on August 15, 1984, set forth many of the necessary elements of such a statement of goals, stronger leadership by the Administration and the Congress is required to build the type of national commitment that will make these elements a reality. Declaration of a set of national goals for our space program is needed to provide a clear basis for national consensus over the years to come. The IEEE United States Activities Board recommends the following declaration:

"Because of the technological and economic advantages to be derived by the nation that maintains leadership in space science, exploration and commercialization, the United States commits itself to maintaining preeminence in these fields. This will require a balanced civilian space program. In addition to replacing the shuttle orbiter and keeping the space station on schedule, the United States must allocate sufficient resources to re-establish a robust civilian space program that achieves the following goals within the next decade:

1. Expand the use of advanced applications satellites for public and commercial purposes to improve worldwide communications, navigation and remote sensing;

2. Expand the number of scientific space missions to extend our knowledge of our planet, our solar system, and the Universe;

3. Develop a mix of launch vehicles, expendable as well as reusable, which ensures greater access to orbit and which provides a broader range of payload capabilities;

4. Encourage the public and commercial use and operation of space systems and facilities;

5. Continue our exploration of the solar system;

6. Support in-space research facilities for our universities; and

7. Sponsor the early development of advanced technology required for long-range goals. The highest priority long-range goals are to reduce sharply the costs of building and using space systems, and to establish human settlements on the moon and Mars."

NASA's future budgets must remain substantially higher than the FY 1986 level to provide the steady commitment necessary to achieve these goals. However, support for them will involve more than simply increased Federal funding. The barriers to private sector investments in space commercialization must be removed, and opportunities for international cooperation must be provided in those endeavors that are appropriate. The possibility of one day making space accessible to the general public must also be considered.

In summary, the IEEE United States Activities Board believes that with appropriate budgetary support, the balanced space program outlined above will yield important benefits to the nation through:

1. New public and commercial services,

2. Increased scientific knowledge, and

3. Advancement of the national technology base.

This balanced program will also ensure regaining United States leadership in space, a primary goal of the Space Act of 1958.

Mr. NELSON. You know, our thinking is right on what both IEEE and AIAA have said. This is what we have been saying the whole way.

Mr. Hesser, you are representing the American Society of Mechanical Engineers. Is there anything you disagree with what IEEE and AIAA have said?

**STATEMENT OF RAYMOND J. HESSER, CHAIRMAN, AEROSPACE DIVISION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS**

Mr. HESSER. No, sir, except we would like to take it one step further in the area of the Shuttle orbiter. We think there is a good case for five orbiters. The statement that we provided you on March 10 was the considered judgment of the task force that was put together, and it represents the policy of these group of experts in the field, not an official position of ASME. My lawyer advisor told me to say this, and I think it is appropriate.

Mr. NELSON. Now, I didn't understand that. You are saying that you support even a fifth orbiter, but you are saying that is not a position of your Society?

Mr. HESSER. The Society is a non-profit society. It is educational, scientific. It is a charitable society founded over 100 years ago. Its membership exceeds 117,000 members, and obviously, aerospace represents but 20 percent of that total, although there are many more involved in second or third tier support of the space program.

Since the space program provides the frontier in technology, that frontier is supported by many practicing mechanical engineers in this country.

Mr. NELSON. Is there anything you would like to amplify on what AIAA and IEEE have said that you said you agree with them save for the issue of an additional orbiter over and above the three plus one that we are going to have in the fleet? By the way, I don't think that there is really any political jeopardy to the replacement for *Challenger*. I know you saw that in some of the news accounts, but I think that was more a budgetary kind of posturing that has gone on.

Now, the Space Station is a different thing. Until we can see to what degree the White House is going to weigh in on this matter from a standpoint of politics, of trying to get something through the funding cycle—that is a different question—but I think the replacement orbiter is okay.

Now, instead of you restating everything that both of these witnesses have said, why don't you amplify on any of the particular points that you say that you agree with?

Mr. HESSER. The major part of NASA's budget, nearly $3.7 million, is devoted to the space transportation system. These funds are designed to support the Shuttle recovery program and cover Shuttle modifications, the Rogers Commission's recommendation and restoration of flight operations during fiscal year 1988.

Our country will have four orbiters when the *Challenger's* replacement is built, and it is the Task Force opinion that a four-orbiter fleet, in our opinion, is still too small to carry out the reasonable space policy in support of our national interests.

We recommend the funding be provided for a fifth orbiter plus sufficient spare parts to enable the fleet to operate without interruption to meet the country's space objective even if one of these orbiters is disabled or being refurbished.

We further recommend the building and refurbishment of the orbiter be planned and carried out in a timely and effective manner so that the support of infrastructure of contractors, subcontractors and vendors be kept intact for the entire lifetime of the Shuttle orbiter fleet——

This manner of managing the Shuttle Program will provide the most space program for the dollar appropriated.

We would also strongly support your committee's proposed addition of $100 million to begin procurement of ELV's to allow NASA to begin to whittle down some of the current launch backlog.

In the area of the Space Station, once again, cost estimates are rising and deployment dates are being pushed further and further back. We have seen estimates in the press and we now know that the price is perhaps escalating to $15 billion or even $21 billion in actual dollars.

Also recently the NASA Administrator Fletcher spoke of deployment in the mid-1990's rather than the original target date of 1994. We are very disappointed that the administration saw fit to provide only $767 million, which is down $288 million from what NASA requested.

If you know how our business works, time is money. You push out the time, you are going to raise the cost.

If, as Mr. Fletcher states, the Space Station reflects the commitment of our nation to our future in space, we question whether the administration is really serious about this commitment. We urge you and Congress to press NASA to provide as soon as possible a detailed cost breakdown of the Station in order to provide a clear picture of the future budget needs and then go after that money.

Mr. NELSON. You know, we asked NASA about that very question that you raised: Why did they bring it down from $1 billion-plus down to $767 million? They didn't have an answer.

Mr. HESSER. The rest of my statement parrots pretty much the statements that have been presented before.

[The prepared statement of Mr. Hesser follows:]

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Statement of the

Task Force on Civilian Space Policy

of the

American Society of Mechanical Engineers

on the

National Aeronautics & Space Administration

FY 1988 Budget Request

Before the

Subcommittee on Space Science and Applications

Committee on Science, Space and Technology

U.S. House of Representatives

March 10, 1987

Introduction

Mr. Chairman, my name is Raymond Hesser and I am Chairman of the Aerospace Division of the American Society of Mechanical Engineers (ASME). We are pleased to have this opportunity to present our views to this Subcommittee, and we thank you for allowing us to appear before you today. This statement represents the considered judgement of the Task Force on Civilian Space Policy, a group of experts in the field, rather than an official position of ASME.

ASME is a non-profit, educational, scientific and charitable society founded over 100 years ago. Membership in ASME exceeds 117,000 mechanical engineers and students. Because of the variety of applications of mechanical engineering, about 20 percent of our membership is directly involved in the aerospace industry. Many more are involved as second or third tier contractors.

In general, we are pleased with the funding levels proposed for the FY 1988 NASA budget considering the continuing pressures to reduce the Federal budget. In fact, the NASA budget was increased by 11.7 percent over the FY 1987 request of $8.5 billion if the special $2.1 billion appropriation for the shuttle replacement is factored out. We are very concerned about some aspects of the space program. We will focus our remarks on a number of areas where we believe improvement in the space program is required. Improvement does not, incidently, equate to greater authorizations or appropriations. It does, however, equate to better long range planning. We also will comment on specific programs which we feel are proceeding in the right direction. Finally, several additional related issues will be addressed.

Space Policy

During the past few fiscal years, most especially FY 1987, we have been very dismayed at what seems to be a total lack of a coordinated U.S. space policy. What we have now is a very disjointed space program which does not really seem to have the confidence of anyone including the American people, the U.S. aerospace industry, or our world partners and allies.

The prime example of the lack of a space policy is in the shuttle program. In the early 1980's there was considerable debate over whether to build a fifth shuttle. The loss of the Challenger, of course, brought the issue to a head. When the Challenger's replacement comes on line in the early 1990's, we will still have just four orbiters trying to do the work of five or six, and probably without sufficient spare parts. We also feel that the lack of long-term planning has contributed to the extended down-time we are currently experiencing in the shuttle fleet.

The final report of the National Commission on Space is a good first draft of a long-range national space policy, but this is precisely all it is - a report. The FY 1988 NASA budget does not reflect a space policy; it merely reflects a stopgap attempt at getting NASA through another year of operation. We recommend that Congress and the Administration place the highest priority on the development of a clear, long range national space policy. We believe that policy should incorporate all aspects of the space program including

advanced satellite development, building and operating a space station with all supporting sub-systems, unmanned space exploration and scientific studies. Such a program should be free of the wasteful stops and starts which characterize the current space program.

Orbiter Fleet Size

The major part of the NASA budget, nearly $3.7 billion, will be devoted to the space transportation system. These funds are designed to support the shuttle recovery program and cover shuttle modifications, the Rogers Commission's recommendations and restoration of flight operations during FY 1988.

As we previously stated, our country will have four orbiters when Challenger's replacement is built and commissioned in the early 1990's. The four orbiter fleet is, in our opinion, too small to carry out a reasonable space policy in support of our national interests. These interests include building the space station, the insertion of certain satellites in orbit, and the servicing and retrieval of these satellites. These national interests should also include experiments in space like the medical, metallurgical and manufacturing experiments flown on earlier shuttle flights.

We seriously doubt if the four orbiter fleet will be able to accomplish all of the above missions. Therefore, we recommend that funding be provided for a five orbiter fleet plus sufficient spare parts to enable the fleet to operate without interruption and meet the country's space objectives even if one of the orbiters is disabled or being refurbished. We further recommend that building and refurbishment of the orbiter be planned and carried out in a timely and effective manner so that the supportive infrastructure of contractors, subcontractors and vendors can be kept intact over the entire lifetime of the shuttle orbiter fleet. This manner of managing the shuttle program will provide the most space program for the dollar appropriated.

The above shuttle fleet, managed properly, would mesh with the manned launch vehicle which NASA is defining to bridge the gap between the current shuttle and the National Aerospace Plane. We fully support this launch vehicle concept.

The current shut-down of the orbiter fleet, due to the Challenger accident, has devastated our space program. Many of the satellites scheduled for launch by the shuttle program have shifted to foreign rivals like the French/European Ariane program and the People's Republic of China's Long March 2 & 3 booster programs. Eventually, Japan will be joining our rivals in the satellite launching business as their National Space Development Agency (NASDA) develops their H-1 and H-2 oxygen/hydrogen boosters.

Meanwhile, in the U.S., many small businesses which provided support equipment for small university or private company experiments have been unable to survive the two-year down-time of the U.S. space shuttle program. They will not be in business by the time another shuttle is launched, and, because of their dismal experience, others who could take their place may not because of the financial risks inherent in dealing with NASA.

Even the large American corporations who can financially survive the

multi-year shuttle downtime, have broken up their many engineering and scientific teams who support various shuttle and shuttle experiment activities and reassigned them to other projects. It will be time consumming and expensive to re-form these teams when the shuttle program resumes in the next year or so.

Unfortunately thousands of aerospace industry employees have lost their jobs due to the Challenger accident. Where will they be when we need them again? The moth-balling of the incomplete shuttle launch facility at Vandenberg Air Force Base in California alone resulted in hundreds of engineers, scientists, and aerospace technicians being laid off or reassigned.

Advanced Communications Technology Satellite (ACTS)

The Advanced Communications Technology Satellite (ACTS) program cancellation is a prime example of the lack of a national space policy. As discussed previously, stop-and-go programs destroy fine teams of industry and government engineers and scientists. It is very difficult to re-form a good science and engineering team when a program is prematurely terminated.

The ACTS program was begun in August 1984 to develop the new technologies to support the communication satellite needs of the future. Current communications satellite operate in the C- and KU- bands (6/4 GHz and 14/12 GHz, respectively) which experience very high propagation losses in heavy rains. Commercial communication companies prefer to compete for orbit/spectrum slots in these low frequency communications bands rather than make the technology investment needed to develop and utilize the higher frequency bands. ACTS will demonstrate economic solutions to the 30/20 - GHz propagation loss problems, and it will provide a communication capacity many times greater than the lower frequency bands combined. Therefore, we recommend reinstating the funds for the ACTS program. We further recommend that the ACTS program be funded to its sucessful completion.

If the ACTS is canceled, this country's lead in the commercial space communication industry will be lost to foreign interests as has occured in our electronics, automobile, and steel industries. By keeping ahead of the rest of the world in the development of advanced satellites, we can preserve jobs for some of our citizens.

Insurance

One of the problems facing the commercial satellite segment of our aerospace industry concerns insuring satellites against loss before they are properly inserted into orbit. In the middle of 1986, space insurance underwriters stopped issuing policies for communication satellites. Prior to the 1986 rash of satellite losses, the historical launch loss rate was about 15 percent so that profitable and attractive premiums could be charged by the underwriters. The 1986 losses increased the space insurance loss ratio to 350 percent. Current insurance premiums in the 20 to 30 percent of cost are so high, the customer will consider flying without insurance. Even with insurance premiums approaching 30 percent, it is not always easy for satellite owners to procure coverage. The France/European Arianspace helps its satellite customers by providing coverage from its own insurance pool in the 11 to 13.2 percent

premium range. This is a great deal considering Ariane's reported loss rate of 28 percent.

We would ask Congress to enact legislation to provide a national satellite launch insurance pool for all hardware launched from American facilities.

International Relations

One area in the space arena where our Nation needs to improve is international relations. We can not unilaterally withdraw form collaborative agreements with foreign countries. We need more international cooperation, not less.

Space debris is building up rapidly, and it will eventually pose problems for future space vehicles. For example, it has been reported recently that French Ariane third stages and U.S. Delta second stages have exploded in orbit after prolonged exposure to the space environment. Several courses of action are available for these situations. First, these upper stages should be designed so that exess fuel is properly burned overboard. Secondly, wherever possible a returning space shuttle should be encouraged to bring back a few defunct satellites. In the case of foreign satellites, permission by and the cooperation with the launching country is mandatory to reduce the possibility of an on board accident with a retrieved satellite. This is one area where international cooperation is need now before the problem gets out of hand.

We recommend integrating more space partnerships into our shuttle program assuming a five orbiter fleet and that the participants pay a fair share of the operational costs. We should also continue to encourage international participation in the space station.

A well defined national space policy supported by the Administration, the the Congress and the American people would facilitate international cooperation by increasing or restoring the confidence in our space programs by our European allies and other countries.

Centaur

We lament the cancellation of the Centaur Program because of the safety concern generated by a liquid fueled payload being carried on the shuttle orbiter. We cite the Tracking and Data Relay Satellite (TDRSS) and other satellite payloads which have liquid fuel rockets integrated into their propulsion units and which have been successfully launched from the shuttle.

Some of NASA's premier space experiments, e.g., Galileo, will be delayed for years because of the Centaur decision.

New Starts

There is only one major new start in FY 1988 with funding of $25 million for the Global Geospace Science Mission. This money will provide for the development of two spacecraft to study the magnetosphere and solar winds. Their launches are planned for 1992. Other new starts such as a comet rendezvous/asteriod flyby missions and the Advanced X-ray Astrophysics Facility Spacebased telescope were discarded during the budget development

process. NASA should give more vigorous support to Space Science and Applications than in past budgets. With the exception of planetary exploration, the other three Science budget lines were increased. Programs such as the Hubble Space Telescope, the Gamma Ray Observatory, the Magellan and the Galileo missions will all be funded. We support the funding of these programs, but we also desire a more aggressive program planned and funded as outlined in the report of the National Commission on Space.

Commercial Programs

Unexpected support is found in the FY 1988 budget for the commercial programs for which funding has increased despite severe setbacks in that industry. An increase of $13 million gives a total of $54 million for FY 1988. Included in the $13 million is an additional $3 million which will be given to technology utilization and a similar amount will go towards the establishment of 3 new centers of commercial development. Four million dollars has been added for the integration of additional joint endeavor experiment (JEA) hardware. This will encourage the commercial space business which has been decimated by the lack of launches until the early 1990's.

Expanding Technology Base

We strongly support the $200 million increase to build up NASA's research and development areas. Substantial increases have been provided for the Aeronautics and Space Technology, Transatmospheric Research and Technology and Space Research and Technology line items. These new levels of funding incorporate the new program called the Civil Space Technology Initiative (CSTI) which is geared to develop the technology base needed during the 1990's for the upcoming launcher systems such as Heavylift Launch Vehicle (HLV) and the National Aerospace Plane (NASP). Technologies such as power systems, on-orbit robotics and orbital propulsion will be researched as well as remote sensing. In FY 1988, $70 million has been allocated to establish CSTI. There is also a continuing NASA investment of $84 million for the NASP program which, added to the contributions of the Department of Defense (DOD) and Defense Advanced Research Projects Agency (DARPA), will total $325 million in FY 1988. The Heavylift Launch Vehicle (HLV) was not supported in the FY 1987 budget but CSTI will provide $25 million to pursue lox-hydrocarbon propellant technology in FY 1988.

Growth in Technical Personnel

In the FY 1988 budget NASA finally recognized that a growing number of its staff are approaching retirement age. Some 625 senior technical people will be added to the NASA payroll to support shuttle and space station activities. This should arrest the decline in NASA's personnel which is now only sixty percent of its Apollo manpower.

NASA is not alone with the problem of the aging technical staff. This is an aerospace industry-wide problem due to the program cancellations, both space and military, in the late Viet-Nam War era. For about 15 years (1967 - 1982), very few new engineers and scientists entered the aerospace industry. As the older technical staff members retire, the new, younger replacements are sometimes required to make decisions for which they lack sufficient technical

experience. This manpower problem also applies to the technical support and production personnel and results in a lot of scrapped parts and cost overruns.

To provide for the development of the space station, NASA has expanded its construction budget for facilities at the Johnson Space Center (JSC) and the Kennedy Space Center (KSC) by $29 million. KSC will benefit from an operations and checkout building for prelaunch assembly of space station hardware and an 1500 man office building, while at JSC there will be a Space Station Support Center, a simulator facility as well as a station flight control facility. We support these facility expansions.

Landsat

Although the Landsat remote sensing program is no longer included in NASA's funding, it nevertheless is an integral part of the U.S. space program.

Since its first launch in 1972, Landsat has been providing vital earth resources to this country and the world, especially to Third World countries in dire need of developing their resources.

After many years of exhausting Governmental review and political debate during the Carter and Reagan administrations, Landsat was finally privatized with the passage of the 1984 Land Remote Sensing Commercialization Act, with the Earth Observation Satellite Company (EOSAT) being selected as the Landsat contractor. This arrangement was based on Government assistance to EOSAT. However, due to the national budget situation, the Government has been slow in providing the promised funds. These funds were zeroed out in the FY 87 budget. However, with $27.5 million appropriated by Congress plus $35 million reprogrammed from the National Oceanic Atmospheric Administration (NOAA) totaling $62.5 million, the $69.5 million required by EOSAT to sustain construction of one follow-on Landsat 6 is almost attained.

The point we make here is that Landsat is fast becoming another sorry example of the Government's on-again-off-again support policy. In this case, France's SPOT Image will gladly take over the free world's remote sensing needs, and another potential U.S. industry will be lost due to the lack of a national space policy.

Expendable Launch Vehicles (ELVs)

We are appalled that NASA has not provided for ELVs in the FY 88 budget. With a crippled shuttle program, there is no way this country can launch the required military and commercial payloads in the next few years without ELVs. We firmly recommend that Congress "encourage" NASA to plan an ELV program in conjunction with the Department of Defense and private contractors to ensure that the U.S. will be able to meet all of its launch committments.

Ideally, commercial contractors would be expected to provide the ELVs for all or most of the commercial satellite launch business, but it has been difficult for these companies to really get started because they were competing with the U.S. Government's subsidy of the shuttle program, or foreign governments subsidizing programs such as ARIANE and Long March.

The good news in the ELV scene is the recently announced DOD/Air Force work to develop the Delta ELV into an advanced medium launch vehicle (MLV). Overall, the Air Force has ordered 20 MLV's, 23 Titan 4's and 13 Titan 2's for the near future. Despite DOD's initiative, it is still a civilian space agency responsibility to plan for and coordinate the needs of the civilian commercial satellite users in this country. We hope that NASA will resume the responsibility - soon!

Space Station

It is ironic to us that the space station planning and development is beginning to resemble that of the space shuttle during the seventies. Once again cost estimates are rising and deployment dates are being pushed further and further back. We have seen estimates in the press that the cost may now have escalated from the original level of $8 billion to as high as $13 - 15 billion. Also recently NASA Administrator Fletcher spoke of deployment in the "mid-1990's" rather than the original target date of 1994.

We are very disappointed that the Administration saw fit to provide only $767 million down $288 million from what NASA requested from the Office of Management and Budget for the space station during FY '88. If the published estimates of a $13 billion total cost are indeed true, we find the $767 million to be even more objectionable. If, as Mr. Fletcher states, the space station reflects the committment of our nation to a future in space, we question whether the Administration is really serious about that commitment.

We would urge you in Congress to press NASA to provide, as soon as possible, a detailed cost breakdown for the station in order to provide a clear picture of future budget needs. We would also encourage you to hold NASA and the Administration to their original deployment date of 1994, assuming all safety considerations can be met. The deployment of the station should not be stretched out indefinately as we have witnessed with other important NASA programs.

Summary

In conclusion, we exhort you, above all else, to strive for an official national space policy supported by the Congress, the Administration and the American people.

We also recommend you encourage NASA and authorize the monies required for: 1) a five orbiter fleet, 2) restoration of the ACTS program , 3) a rejuvinated planetary exploration program, 4) a coordinated expendable launch vehicle program, and 5) restoration of the space station program to its more ambitious initial schedule.

In addition, we urge you to provide the enabling legislation to provide a national satellite and launch insurance pool for all hardware launched from American facilities and to encourage better international space relations with our friends and allies and even the Soviet Union.

Thank you again for this opportunity to present our views concerning the NASA budget and space program.

## Acknowledgements

Members of the ASME Aerospace Division Task Force on Civilian Space Policy which developed this statement are:

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Mr. John W. Robinson; Task Force Chairman
Former Chairman, ASME Aerospace Division

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Mr. Louis Hemmerdinger, P.E.; Former Chairman, ASME Long Island Section

Mr. Phillip J. Legendre, P.E.; Former Chairman, ASME California Inland and
Los Angeles Sections
Public Affairs Chairman, ASME Aerospace Division

Mr. Donald J. Simkin; Member, ASME Aerospace Division

Mr. NELSON. All right.

Dr. Wilson, what do you agree or disagree with that has gone on before?

**STATEMENT OF DR. GLEN P. WILSON, EXECUTIVE DIRECTOR, NATIONAL SPACE SOCIETY, ACCOMPANIED BY GORDON WOODCOCK, PRESIDENT, L-5 SOCIETY**

Dr. WILSON. Mr. Chairman, I think our position would be that we would agree pretty much with everything that has been said, and even to the extent of supporting a fifth orbiter, maybe a sixth or a seventh. We tend to look a little beyond some of these things.

If anything, in the total picture, our expenditure for our civilian space program is simply too low. It is less than half what it was in real dollars or current year dollars 20 years ago, and we simply cannot in this country maintain a leadership position in space at the levels we are talking about.

We can quibble about a fourth or a fifth orbiter or whether we should do this or that or the other mission. I am talking about levels of activity. It is the level of activity that is too small.

Now, I wanted to say this about Mr. Bova, our president. He was not able to be here today and he sends his regrets on that. His statement you do have for the record——

I also wanted to mention that in previous years we have submitted to you a survey of our members and what they feel about the space program. We don't have that all tabulated yet. I would like to submit that later for the record.

The thrust of Mr. Bova's statement is that we really shouldn't try to do this program on the cheap. Let's don't build the cheapest Space Station we can build; let's build the best one we can build because, if not, we may find ourselves in the situation in 10 or 15 years in the same place we are now, of wringing our hands and putting up the black crepe because some astronauts died in space because we tried to build a cheap Space Station and not the best one we could build.

I think that is one of the main points in Mr. Bova's statement, and I could just add to that, we could paraphrase what President Kennedy said in May of 1961 when he urged the country to go to the Moon, to accept the Moon as a goal; that if we were not prepared to take the risks and if we weren't prepared to pay the price to do that and know that it was going to be difficult and expensive, then it would be better that we wouldn't try at all.

So if we are not going to build the best Space Station that we could build, maybe it would be best not to build it at all. There are going to be space stations out there. They may not be ours.

Mr. NELSON. There already are.

Dr. WILSON. Yes, sir.

One other thing I wanted to say is that I wanted to announce with great pleasure that the merger between our organization and the L-5 Society is finally taking place and will be a legal reality within another week or so. I am very happy to have with us here today Gordon Woodcock, who is currently President of the L-5 Society, and this time next week or so, he will be the Chairman of the Executive Committee of the National Space Society.

So we are very happy to have that merger completed. We think that the combined merged organization will put us in a better position to help bring this message to the American people.

I would like to, at the risk of perhaps cutting us out of testifying next year, to point out to you that we do not consider ourselves a professional society. The National Space Society as it was envisioned by Dr. Werner von Braun when he founded it in 1974 is a citizen's group. It is a group of citizens who support a strong civilian space program. In fact, our surveys show that not more than six or seven percent of our members are actually employed in the space industry—the space business. They are interested citizens in the space program.

So with that, I would like to ask Mr. Woodcock if he has a few comments. Also, we have submitted through Mr. Woodcock for the record answers to some of your specific questions.

[The prepared statement of Mr. Bova follows:]

National Space Society
promoting development of the Final Frontier

STATEMENT OF

Given by Dr Bean Wilson

BEN BOVA
PRESIDENT
NATIONAL SPACE SOCIETY

BEFORE THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

10 MARCH 1987

(HOLD FOR RELEASE UNTIL PRESENTED BY WITNESS)

West Wing Suite 203 • 600 Maryland Avenue, S.W. • Washington, D.C. 20024 • (202) 484-1111
Formerly the National Space Institute

Statement of
Ben Bova
President, National Space Society
before the
Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
House of Representatives
10 March 1987

Mr. Chairman, and Members of the Subcommittee:

It is both an honor and a deep responsibility to address you today. As president of the National Space Society, I speak for nearly fifteen thousands members from all walks of life, all regions of our nation and even of other nations.

As you may know, the National Space Society has recently merged with the L-5 Society. Our organization will sponsor the Sixth Space Development in Pittsburgh later this month (27-29 March). Our members are active and anxious for you to hear what they have to say about exploring and developing the space frontier.

Their message to you is simple and heartfelt. It is this: America must move forward bravely and boldly in space. The tragedies of the past must not be allowed to overwhelm the realities of the present or the promises of the future.

You members of Congress hold the fate of our space program in your hands. More than that, you bear the

responsibility for the safety of the men and women who will live and work in space over the coming years.

Since the disaster of Challenger, the National Space Society has sponsored a series of public meetings in major cities across the nation. Standing-room audiences at each of these meetings had their chance to say what they felt about our efforts in space.

They made it clear that the American public expects us to move forward in space, as swiftly and as broadly as we can.

Some fifteen years ago, a different Administration and a different Congress made decisions about our space program that led directly to the disaster of Challenger last January. I urge you -- our combined membership urges you -- not to repeat that same sad history of short-sightedness. The decisions you make this year will not only shape our efforts in space for many years to come -- they will determine whether or not the people who work on the space station in the 1990s will face the same deadly risks that our shuttle astronauts faced.

I repeat: their lives are in your hands. By cutting corners on the space station program this year, you may well be sentencing brave men and women to their deaths in the next decade.

Funding decisions are always difficult. There are always competing pressures. But I ask you to consider

from technology developed originally in our space program.

In the years to come, entire new industries will begin to take shape in space itself. Microgravity processing will make important inputs to pharmaceuticals, plastics, electronics and metallurgy, to name merely one of these new possibilities. At our conferences, scientists and engineers describe ideas and present technical designs for industrial developments and settlements in space, things that may bring about the next industrial revolution.

Other nations realize this and are taking steps to move ahead of us in space. The Western Europeans are already competing with us in launching services and remote sensing. They are designing their own space stations and proposing advanced launchers that will leapfrog our shuttle. The Japanese are moving forward swiftly now, and three American satellites will be launched in coming months by the Peoples Republic of China. Even the Soviet Union has established its version of a commercial space office, to solicit foreign business away from the West.

Faced with these opportunities, and this new commercial competition, it is urgent that you take the steps necessary to make America once again preeminent in space. We must establish the best and safest space station we can possibly build, not the cheapest. That is the first step

on the road to economic prosperity in the 21st century. We must formulate bold policies and plans for developing the space frontier along the paths outlined by the National Commission on Space.

If we fail to take these steps. If we are hesitant or slipshod or shortsighted, America will not be a first-rate economic power in the 21st century. Or even in the 1990s, I fear. And without a strong economic base, our political power will erode. Eventually even the freedoms we take for granted can slip away from us if we do not maintain a vital and growing economic base.

These decisions are yours to make. Take the first steps toward re-establishing our preeminence in space, or take the first steps toward a future of poverty and despair. That is the choice before you.

Thank you.

Mr. NELSON. You share with us anything different than what has gone before us here, Mr. Woodcock.

Mr. WOODCOCK. Thank you. I will try to confine my remarks to a couple of additions and not repeat what other people have said.

One thing that seems to have circulated around the public press a good bit recently on the subject of the Space Station—I think this is one additional comment on the Space Station—is the question of, until we decide this long-range policy that we are discussing, do we really know what kind of Space Station to build? I would like to submit that since the Space Station is infrastructure, it is very much like an office building that a contractor would build for purposes of renting out to various customers, and if the contractors had to know exactly who they were going to rent it to once they got it built, very few would build office buildings because you just don't know.

In fact, like Earth-based infrastructure, a good space-based infrastructure is a sound investment regardless of the specific mission that one has in mind.

A couple of things that our members expressed considerable concern about in the future of space planning for this country is whether or not our programs are designed to really benefit and capitalize on the economic potentials of the space frontier. Recognizing that those potentials certainly have some uncertainties to them, nonetheless many of our members believe—and I believe—that there is a great economic potential out there and that we need to be always in mind of being able to capitalize on that.

I believe Mr. Bova pointed out in his testimony that for an investment of some $130 billions in civilian space over the years, that our economy now, about a half-trillion dollars a year comes from the technologies that came out of that program, and those are the technologies that are supporting the growth part of our economy. Those are the technologies where we are the most competitive in the world today.

Another thing that I think we need to take to heart is that this process, this business of developing a space future for the country really is a public business. Sometimes I think we look to NASA to tell us what we ought to do in space, and we shouldn't be doing that. We should be looking to the country at large and the various experts in the country to develop our long-range goals in space, to have a national commitment and not just a recommendation on the part of a particular agency as to what our program should be.

Our members were very enthusiastic about the Commission on Space Report. Our people generally feel that the key words in that report are "frontier" and "settlement" and "low cost access," and not necessarily with reference to any particular space definition. They are very interested in the potentials that it offers.

I think some of them are perhaps a little bit too satisfied or they are inclined to believe that the NCOS report in some way represents an actual national plan, which, of course, it doesn't, but they are very encouraged that we are at least thinking in those kinds of directions.

Mr. NELSON. Let me stop you right there and ask you. You know, that National Commission on Space Report is like a gem that has been undiscovered. That really is the basis upon which we ought to

be having some discussion about what should be America's future space program, and yet it did not get the attention nor the circulation that it should.

What could you advise us to do other than the fact that we had a hearing last year to try to get it? Nobody showed up. When I say nobody showed up, not very much press attention. We thought that we might do that again this year just simply to focus on the substance that is in that report. What do you think, Dr. Wilson?

Dr. WILSON. We were quite concerned about that, and as a result we had a symposium series and we are still in the process of that. We have had six major symposia around the country. They have all been well attended, standing room only. On a very dreary day in New York City on a Saturday afternoon last November, we had a standing room only audience. We had to get an extra room in the hotel for people to come listen. But then again, that is not the sort of thing you see on the front page of the newspaper.

What I am saying is we made a real effort to bring the discussion of the National Commission on Space Report to the American people, and we have two more of those symposia scheduled now, one for Huntsville and another one for San Francisco, and we hope to have some additional such programs this fall if we can get the right support for it.

You are right. Somebody needs to get out there and tell the people about this report, and we are trying.

Mr. NELSON. Or in the alternative, maybe we ought to be getting out there listening to the people because what the people want is nothing less than the best when it comes to their Space Program.

Mr. WOODCOCK. That is really true. We really find that. I think both NSS and ourselves have found that. One of the reasons for this merger, we have found our membership really interested in the same thing, so there are benefits to getting together.

I think one thing that we feel and a lot of our people, and perhaps not the majority of our members, by any stretch of the imagination, but we have a number of people that are really in the front of the high tech industries in this country and they are very concerned over the economic competitiveness of this country, and they feel that really doing some of the right kinds of things in space—including having specific goals, which tend to drive people to objectives and you tend to make progress a lot faster if you know where you are going—that things are of great importance to this country.

I will come back once again, finally, to the low cost access business, that we really need that low cost access. In the interim, of course, we need to restore the Shuttle fleet, and our membership has always endorsed that. Our membership has always endorsed the Space Station. We think we need to do that and do that right. We think that without a Space Station, our future in space is really going to be stunted and constrained.

But it keeps coming back to the low cost access. A lot of our members are people who would like to someday make a career in space, and the costs are too high today.

One of the questions you asked on technology, I would like to make a few specific recommendations relating to low cost access, and I will simply enumerate them and not discuss them. They are discussed a little bit in the testimony. Low cost access in the long

run means some kind of system that we can operate like an airliner. Yes, I know we hoped to do that with the Shuttle and we didn't quite get there, but we still can do that in the future.

It needs, in addition to the advanced rocket engine technology that has been discussed, a genuinely reusable hydrogen insulation that will be a part of a tank structure and survive for 1000 flights or so.

We need a TPS that we are not quite so afraid to fly in the rain. We need a TPS that will be easier to restore. I know NASA has done a great deal of work there and there is a lot of latent technology in that TPS world out there.

We need to develop auxiliary power and propulsion systems that are entirely hydrogen-oxygen driven so that we are not faced with the problem of loading toxic and corrosive propellants into vehicles as a part of the turn-around cycle. It takes a long time, it is dangerous and it is difficult.

Then finally, I think we need to be pushing pretty hard in the technology of control configured vehicles that can do the same kinds of things aerodynamically for less structural weight and better balance.

There are some other recommendations in our testimony but they tend to look a little bit further in the future, and I think in the interest of time I believe I will skip over them at this point.

That completes our testimony, and like everyone else, I think we are ready to answer questions.

[The prepared statement of Mr. Woodcock follows:]

Statement of

Gordon R. Woodcock

President, L5 Society

before the

Subcommittee on Space Science and Applications

Committee on Science, Space, and Technology

House of Representatives

10 March 1987

Mr: Chairman and Members of the Subcommittee:

I am honored to have the opportunity to address you today in cooperation with the National Space Society, with which we expect to be merged later this month.

The L5 Society strongly endorses the NASA space station as well as the construction of a replacement shuttle orbiter, as we have in the past. We believe these systems are essential underpinnings of a sound and vigorous space program.

The shuttle and the space station are infrastructure, not missions themselves. For this reason, some people have raised the question whether we know what shuttle and space station to build, since we have not decided on longer-range mission goals. I would answer that for space just as for Earth-based infrastructure (like an office building or a truck), it is not necessary to know

exactly the eventual use in order to design and build suitable infrastructure. This is certainly true of the space station. NASA plans to build a basic core space station; it is the proper building block for any plausible future U. S. space endeavors.

As to whether a space station is needed: lack of a space station would surely stunt the growth of our space activities whatever course we choose. Whether we essay to exploit the space frontier for industry and commerce, or push back the frontier through human exploration, or both, a space station is essential. We undoubtedly would have been better off in the long run to have built a space station staging base for the Apollo mission as originally proposed by von Braun. We probably would not have reached the Moon "before this decade is out", and that is the main reason we didn't go to the Moon by way of a space station in those days. We should not make that mistake again.

This question of where America is going in space is the one we hear more about from our members than anything else. L5 has consistently endorsed NASA's main programs, both for science and for infrastructure development. Our members ask us to do more; to speak out for what America should be doing in space. They wonder why it is so easy for the Russians to put up space stations. They tell us, and our polls of the American people tell us the same thing, that they want the American space program to aggressively develop the economic potential of the space frontier. They want low-cost access to space on a large scale; they hailed



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the recommendations of the National Commission on Space, especially on this point. They hear distinguished scientists and engineers at conferences speaking to development of resources of the Moon and eventually the asteroids. They wonder why more isn't being done about these matters. They are concerned that America is becoming a second-rate space power. They wonder if anyone in Washington cares.

I believe a common failing on the part of all of us is that we tend to look to NASA for all the answers. NASA has done a great job of implementing our American civil space program. Yes, despite Challenger, I will repeat: NASA has done a great job. Often NASA has been given inadequate resources and inconsistent policy, and perhaps, has at times tried to do too much for too little. But formulating civil space policy is not NASA's job. If NASA did that task well, NASA would run the risk of criticism for being self-serving. Civil space policy is the job of the people and the people's representatives in the Congress and the Administration.

It is, indeed, time to look forward and to choose paths. It is already late to be sowing the seeds that will grow a space-based industrial revolution in the next century. Even though it shouldn't be, the space station is mired in uncertainty about where America is going in space. The shuttle is over-subscribed and we have no plan to correct that situation except to patch things up as best we can with expendable launch vehicles.

This is not to denigrate ELVs, but rather simply to say that we haven't yet defined a real path to the future. Expendable launchers have a very important role to play in our space future. We need a commercial space launch industry to compete in the international market place, and it surely must start with ELVs. Using ELVs to develop market position, this industry can prepare itself to become a major new U.S. commercial/industrial sector. The federal government should develop the technology for a second generation, fully reusable vehicle today ... and then turn the results over to a commercial industry to develop into an operational system, to become the low-cost access to space that the NCOS report calls for.

We should immediately begin to develop the technological base and plan for a joint government-private return to the Moon, this time to stay. It is amazing that after this nation spent some $80 billion (in today's dollars) to put twelve men on the Moon, for the last ten years the most productive research into using the resources of the Moon for economic benefit has been done not by NASA but by a private charity, the Space Studies Institute. L5 and SSI have worked together on some of this research. This is a startling reversal of the usual government/private sector role, in which high-risk, long-term research potentially benficial to society at large is publicly-funded. Clearly, we need a national effort.

We believe the NCOS report is an historic milestone because it recognizes for the first time the real potential of the space frontier. The key words in that report are "frontier" and "settlement" and "low-cost access", not any particular space destination. There is every reason to believe that low-cost access would open the space frontier as the railroads opened the West. America, however, does not own the space frontier as we did the West. There are many nations aspiring to build space railroads, and factories, and homesteads, thus to reap the riches of the inner solar system. It is an economic competition we can ill afford to lose. If we don't move out briskly to open the space frontier, we can expect to find a sign saying "Occupied ... Do Not Disturb" when we finally arrive there.

Additional Statement of

Gordon Woodcock

President, L5 Society

Specifically Relating to Issues Raised in

Chairman Bill Nelson's Letter of February 26, 1987

## Expendable Launch Vehicles

We have not made an exhaustive analysis of NASA's needs in the expendable launch vehicle area. It is our perception that NASA has missions that could use ELVs, thus helping to work off the Shuttle backlog. This raises the question of how and when NASA should buy ELVs. The cause of establishing a viable commercial ELV industry would be well served if NASA would fill its ELV needs by purchases from the commercial offerors, either purchasing vehicles, or even better, purchasing launch services as do private sector industries requiring such services. If the usual commercial arrangements apply, the cost to the government for launches would be deferred by purchasing launch services instead of systems. NASA has an opportunity to do some pioneering here.

## New Technology Initiatives

We must evaluate technology initiatives in the context of the

long-term future of our space program. We fund technology initiatives so that at some future time when a program decision is to be taken, the technology essential to the success of the program will be understood well enough to make positive program decisions with confidence that we can deliver the goods, on time and on budget.

The best model, and essentially the only model with any official status, for the long-range future of U. S. civil space development, is the report of the National Commission on Space (NCOS). Our recommendations are based on the NCOS goals.

The NCOS made a strong recommendation for low-cost access to space, meaning a low-cost launch service. We have here a sort of chicken and egg situation, or one might call it a "Catch-22", to invoke another cliche. At today's traffic levels, we will have no such thing as a low cost launch. The overhead costs of running a space transportation service, either government or commercial, are simply too high. But unless we reduce launch costs, we are likely to be stuck at today's traffic levels.

There is a possible way out. If we develop a second-generation system capable of low cost at high launch rates, and accept the development cost as a national investment rather than an investment to be recovered from traffic revenues, then it is possible to have a space transportation service that can, with

increases in traffic, reduce cost fast enough to go into an economic boostrap to high traffic and low cost. What is needed is a fully reusable, routinely operable launch system. There are several technology needs:

(1) Improved re-entry thermal protection for all-weather operation, minimum refurbishment, and fast turnaround.

(2) Genuinely reusable liquid hydrogen insulation that is an integral part of the vehicle tank structure, light in weight, and capable of at least 1000 flights without replacement.

(3) All-oxygen-hydrogen auxiliary propulsion and power to eliminate toxic and corrosive propellants from vehicle systems, enabling simplification and streamlining of turnaround operations.

(4) All-electric actuation systems, eliminating hydraulics and pneumatics and capable of capitalizing on efficient, flexible fuel cell electricity for auxiliary power.

(5) Accelerated technology development and demonstration, through breadboard and brassboard test engines, of a booster engine in the 750K thrust class and an advanced hydrogen-oxygen space engine in the 10 to 20K thrust class.

Real development of space as a frontier will begin with lunar

and planetary surface operations. Beyond low-cost access to space, the next economic choke point for these operations is cargo and resupply delivery from Earth. The only recourse is to use extraterrestrial resources for consumables and construction materials. Exploratory studies and experiments have been conducted by JPL, SSI, and NASA. The results are very promising but very preliminary. We need to put more emphasis on this infant technology. More is still not very much, and it does not now need major emphasis. It does need to become a respectable area of technology research with enough funding, such as a few millions annually, to attract institutional interest and the participation of more first-class research people.

A companion technology need is that of adequate power. On planetary bodies, this means solar or nuclear power, and if we are to obtain enough power for industrial processing of planetary resources, it very likely means nuclear power at least for a certain period of time. Early lunar and Mars surface operations can use solar power if an efficient electrical storage means is available. Industrial applications, even on a very modest scale, quickly get into the multi-hundred-kilowatt range where nuclear power is attractive. Still farther into the future, in a multi-hundred-megawatt era, power beamed from satellite power stations might prove attractive. This last option is far enough in the future that it does not need immediate technology attention.

These considerations lead us to two power technology recommendations:

(1) Develop regenerable fuel cell technology for solar-generated electrical energy storage. Its performance advantages on the surface of the Moon or Mars, over batteries or thermal storage, are decisive.

(2) Ensure that space nuclear power development activities, such as the SP-100 program, stay on track and produce reactor power system options that are usable on a planetary surface.

There are, of course, many other civil space technology areas of interest. Many of those most relevant and not mentioned above are being developed for the space station program. Space station developments, such as in regenerable life support, are fully applicable to the future goals proposed by the NCOS.

Mr. NELSON. Thank you very much.

Mrs. Morella, and then Mr. Perkins.

Mrs. MORELLA. Thank you very much. I enjoyed the testimony that I heard, and I guess I have two questions. One has to do with the Space Station. I think I heard some contradictory testimony from Mr. Flajser and, I think, Mr. Hesser.

I think you said, Mr. Flajser, we should hold back a bit till we make sure that we have an adequate policy before we move ahead, and I think Mr. Hesser said we must move ahead because of competitiveness and whatever. I do have a concern about whether we are ready for this yet; not that we don't need it, but whether we might be wiser to move in smaller steps or smaller increments, and I wondered if you might both just briefly address that possibility.

Mr. HESSER. I will just say what my concern and what my Society's concern is, is that we want to see the Space Station program continued. If you are overly concerned with costs like you were with the Shuttle, that continuation will become riskier and riskier because you are going to keep turning the crank on the costs, and the risk goes up. We don't want to see another disaster in space, and I think that is basically what we are saying.

You have taken $288 million out of this next year's budget, and when you do that, when you take something, you have to give something, and what are you going to give?

Mrs. MORELLA. But it is a substantial increase from last year's budget?

Mr. HESSER. Yes, but last year we were not at the same point in the design cycle. We were just in the conceptual phase.

Mrs. MORELLA. Would you like to comment on it, Mr. Flajser?

Mr. FLAJSER. Mrs. Morella, we perhaps would describe our statement as cautious. With regard to the Space Station, we have supported Space Station development for several years now. There are so many things that enter into judgment as to whether to proceed with the Space Station development that when you are faced with the Challenger accident last year, when you are faced with significant Federal budget deficits, when you are faced with cost growth, when you are faced with a lot of other uncertainties, the picture gets a little murky.

One of the things we see is that much of the discussion is focused on the Space Station as an end in itself, and we encourage the Space Station as a means to some other ends. We haven't focused on those ends, and that, I believe, was the point of the statement, is to try to figure out what it is we are trying to accomplish and then take the Space Station down that road, rather than proceed with some specific Space Station development and then figure out later what we are going to do with it.

The cost implications of that are significant and grow to be even more significant with time. There is no question, though, with regard to support of the Space Station development, it is the context within which it is going to be developed, and secondly is the whole notion of the balance: where does it fit in relative to everything else?

If you were to proceed with a Space Station development and you're budget limited in that relatively few other things were going to proceed, that would cause a great deal of heartburn because you

don't come up with what we would propose as a balanced space initiative, balanced space program.

So I wouldn't put it that it is contradictory so much as it is growing more cautious with all the ramifications of that not-insignificant budget allocation.

Mrs. MORELLA. I think also we are not really sure what it is going to cost or really what it is going to do, and I think that may be something that suggests that we should be cautious in approving the funding.

Mr. LOGSDON. Could I make a comment on that? I think the Congress, the committee needs to take a step back and recognize what is going on with respect to the Station. The budget request from NASA went into the NASA budget, to the White House last August, in September was negotiated through the fall, came up in the President's budget in January.

Last July and August was a very troubled time in the civilian space agency. I think mutually inconsistent schedules put us in the unfortunate position of you, as members of Congress, having to decide on a fiscal 1988 budget which won't go into effect next fall with incomplete information, and I can understand the problem that that causes for you.

I think what you see is the civilian space agency and the White House trying to learn from the Shuttle experience, recognize that the Shuttle was underfunded at the start, that the context in which it would take place wasn't carefully understood, and on the basis of some, in my judgment, poor quality decisions in 1972 and 1973, we get into trouble in 1986 and 1987.

So I think what is going on now is a very intense effort to make sure that the station we build is understood at the start for what it is, what it can do and what it is going to cost, and I think that all of those elements are going to be emerging in the next month or two. They represent intense work since last summer at the same time NASA has been trying to get the Shuttle back to flying status, and essentially there is an overload there.

The best people in this country have been studying the Station now for three years since the President's announcement in 1984. Over a half-billion dollars have been spent on that study. To think that there isn't a clear idea of what we can do, how much it is going to cost and what it is for because it is not on paper now in front of the Congress, I think, is a little too narrow a perspective. It is unfortunate that this couldn't all be done so it could come up with this budget in a neat and timely fashion, but I think the purposes of the enterprise are, in fact, clear. They are to have a national facility in space so that when we are there, we can learn what to do, how to do it, how to exploit the space environment and prepare for leaving the immediate vicinity of this planet and going out.

Mrs. MORELLA. Thank you. I guess the facts are going to have to emerge soon.

Mr. WALKER. Would the gentle-lady yield?

Mrs. MORELLA. Indeed.

Mr. WALKER. The one problem that concerns me about your statement, though, is that based upon the testimony we have heard prior to yours before this subcommittee and then backed up by

what you have just told us, what we are being asked to do is sign a blank check, and I will tell you that that is not going to happen.

You know, even if this subcommittee, with our involvement in the program, was willing to sign a blank check, and even if the Science, Space, and Technology Committee was willing to sign a blank check because we have faith, I will guarantee you that the House of Representatives is not willing to sign a blank check.

Mr. LOGSDON. Nor should it.

Mr. WALKER. But you know, if we are told that everybody is studying this and we all understand it, and then we ask people when they come up here to testify to us to explain it to us what it is we now understand, and the answers we get out of the experts are, well, you know, that's all coming later, the fact is we are going to mark up a bill on the 31st of this month, and if we don't have an understanding of it at that point, we are going to have a great deal of difficulty with that particular program. I will tell you, I have got a concern about it.

Mr. LOGSDON. I think the concern is merited.

Mr. WALKER. Thank you.

Thank you for yielding.

Mrs. MORELLA. Thank you.

Mr. Chairman, is it all right to ask another question?

Mr. NELSON. Surely.

Mrs. MORELLA. Thank you. It has to do with the ACTS. What I am curious about is whether or not industry plans to have a role in helping maybe with the financing of ACTS since the idea is that it is also going to help industry. I am curious about whether anybody, not directed to any one person, may have a comment on that.

Mr. FLAJSER. I will wade in on this one, I guess. That question came up particularly a year ago when the proposal once again to go ahead with ACTS did not make it out of OMB on its way to the Congress. One of the arguments was that if ACTS, in fact, did have all this commercial benefit downstream, that the industry should pick up or somehow finance the program.

The response to that essentially is that, number one, historically the role of industry has been to pick up where NASA leaves off. That is, once the high-risk R&D, proof-of-concept work is demonstrated, then industry invests in the commercial systems and builds the satellites after that.

The risk involved and the cost of this R&D initiative is so vast that not one company, let alone the entire satellite communications industry per se, has that kind of R&D budget to support the ACTS program in toto. At this stage of the game, with the ACTS program already funded far beyond half completion, it doesn't make really economic sense to terminate at this particular point in time.

Mrs. MORELLA. So you feel that if it is continued, ultimately the cost for industry or the private sector to get involved would be low enough so they could jump into it.

Mr. FLAJSER. That's right, once the proof-of-concept is developed, at that point they will continue to put more money into the system.

Mr. HIEATT. I would like to make a comment. What industry will do is to take that technology and competitively exploit it in a com-

petitive sense. It would be very hard to get the people that are going to use that technology to pool their funds. Do you understand what I am saying?

Mrs. MORELLA. Yes.

Mr. HIEATT. In other words, what NASA will do is to prove that the idea of position multiplexing works. Then industry will go out and take what they can gather in the way of the design concepts and try and build a better mousetrap using that concept. That is the way industry picks up. But we need the ACTS to demonstrate that.

Mrs. MORELLA. We don't have that many great pioneers because of the money and the competitiveness.

Mr. HIEATT. Well, there is so much invested that you can't sell it to the stockholders. You don't get your money back in time, or you can't prove you are going to get it back.

Mrs. MORELLA. Thank you, Mr. Chairman.

Mr. WILSON. Mrs. Morella, it is simply a question of who is going to take the risk and at what point. I can recall once in the early seventies when the distinguished head of the Office of Management and Budget said that he didn't want to fund the Shuttle because if it was that important, thou the airline people might want to pick it up. Of course, we would never have had a Shuttle under those circumstances.

There is a certain amount of risk that the Federal Government has to take on these things, and if they don't take the risks, then they won't be taken here; they will be taken somewhere else, in France or Japan or wherever.

Mrs. MORELLA. Thank you very much.

Thank you, Mr. Chairman.

Mr. PERKINS. When I read these statements, one thing that strikes me that I hear over and over again is the idea that we have got to have some type of goal, albeit a short-term goal, intermediate-term goal or long-term goal. Yet all that I seem to hear in terms of testimony, with some exceptions, I think, is an emphasis upon the short-term goals.

It strikes me that we would be better served by perhaps an emphasis on a more intermediate-term goal. Dr. Sagan, I guess, the Planetary Society, I know a number of you are interested in the Mars mission and think that should be an intermediate-term goal. Do you think that is a viable goal or do you think rather a goal should be some sort of independent human settlement in space, not necessarily on Mars, but independent of Earth for supplies, et cetera.

I guess the National Commission on Space seems to go through one to get to the other, but what goal out there on the intermediate term do you think we ought to be reaching for?

Mr. WOODCOCK. Mr. Perkins, of course, the L-5 Society has been always interested in long-term goals, but we think in terms of space goals as not being a specific kind of a goal like landing a man on Mars, but more a goal of what is it that you are trying to get out of your space program in the long run?

What we think that one should be trying to get out of the space program in the long run is large-scale space industrialization and settlement—very definitely a long-run goal. With regard to inter-

mediate goals and intermediate policy, you have got to talk about things that can benefit the country and provide guidance and structure and leadership to the overall program. I would think in terms of things like low cost access.

Mr. PERKINS. The Commission on Space says that they want to have by the late nineties $200.00 a pound access to space? Isn't that the figure that I seem to recall?

Mr. WOODCOCK. That was their figure, yes.

Mr. PERKINS. What do you think is a viable figure that would allow us the economic reality of access to space with the problems that we have of capitalization for new-type industry. The capitalization question and what they are willing to expend is something that we definitely have to look at.

I know just out of odd coincidence I read a book by Mr. Bova last week called "Privateers" that had a number of things to do with something that we are talking about both in terms of U.S. involvement in the space effort and in terms of economic access to space. The thrust of the thing, though, seems to me that we are still a good ways away from having the type of access that we need to space and to a commercial network in space because of the capitalization problem to make a real economic impact with the private sector in space.

What types of developmental things do you think are necessary for us to try to get to that stage where perhaps then economic capitalism could allow us to take off into the long-term type society that you were talking about?

Mr. WOODCOCK. Very specifically in the area of low-cost access, we see a two-pronged approach to that as maybe the only way to get there. One is to encourage, and which I know this Committee has, to encourage and stimulate a commercial launch service which is going to have to start with expendable launch vehicles because it's the only way you can start an industry today in that area. Combined with Government funded investment in the technologies that will eventually support this $200 a pound kind of thing at some point in the future.

Again, I would remind you that Space Station is an essential part of that overall infrastructure, but the $200 a pound specifically comes from some kind of an advanced launch system. But you've got to have——

Mr. PERKINS. Could I just jump in here for one second?

Mr. WOODCOCK. Sure.

Mr. PERKINS. And just talk about the Space Station for a second, and I want to share some concerns that I had with this.

You know, in trying to get information about where we're going with the Space Station, it's very difficult. As I'm sure Dr. Logsdon has commented, we've had a period of time where our best experts perhaps have been looking at this for a period of the last 3 years. At the same time, we're sitting here as Congressmen, not sure of what—not even having just only vague ideas—as to what we're talking about doing with the Space Station.

What is the purpose of this Space Station? Is it just an overall outreach program, or do we have something that we want to make use of this Space Station as perhaps down the line, as for example

the National Commission on Space indicates transporting it to a point to become a part later of a Mars mission.

What are some of the various options that we can utilize and build into the Space Station at this stage that we—that you think are important that we need to know about?

Mr. WOODCOCK. Well, the Space Station that's presently planned is designed basically to serve as a national developmental laboratory in low Earth orbit. It encompasses several kinds of things, including the materials processing research that was brought up. You've probably heard all of that stuff, and I won't repeat it. That's where you have to start.

Mr. PERKINS. That's a start. But let's get beyond that.

Mr. WOODCOCK. Where you can go beyond that is very hard to predict, particularly since we really don't have a long-range objective, or a long-range space policy in this country.

Mr. PERKINS. I think that's very true.

Mr. WOODCOCK. Okay. But there's a couple of ways that you can think about going. And one of them that could very well happen by itself, and I'm not wise enough to predict, is a significant commercial development on the edge of space right there in lower Earth orbit, based on things that we might learn in operating a Space Station. Again you have to say that since we haven't learned them yet it might not happen.

Secondly, if the Nation were to establish a long-range goal of a return to the moon, or a mission to Mars, or whatever, then the Space Station will both develop some of the critical life support and life sciences technologies that we need to do any of those kind of things, as well as serve as a stepping off point to do those kinds of missions. So those are kinds of options that one has.

Mr. PERKINS. Do we need at this stage to try to develop a longer term space policy so that within that framework we can view the Space Station as having this place?

Mr. WOODCOCK. Obviously we need to develop a longer range space policy. I think it's a mistake to always hold back and say, until you know exactly what you are going to use something for, don't start it. And I heard the same kind of arguments 15 years ago with respect to the space Shuttle. The most innovative things that we have learned about how to use the space shuttle are things that nobody thought about in 1971 and 1972, when they did all these grandiose traffic model studies. So that, you know, to say that you have to know exactly what you're going to use something for is——

Mr. PERKINS. Understood. And understand that the technological variable new uses is always the thing that's the greatest thing that comes from it.

Mr. WOODCOCK. Sure.

Mr. PERKINS. Even with that, it strikes me that we're looking around for some specific direction, some overall final goal. Not a final, but some goal somewhere out there that drives us, as someone said earlier.

If you have a goal it seems that things fall more efficiently and quickly into place. And it strikes me as one of the things that I'm interested in hearing, when I come to something like this, is some sort of overall plan of where we want to go, maybe even why. You

know, it's like I don't want to be bogged down at this stage with what it's going to cost.

I mean, everyone knows is that we're talking a tremendous investment over the long term. Incidentally, I'd love to substantiate the $130 billion invested for the one-half trillion that we get out of it every year. I'm not doubting it. I'd just love to see substantiation of it. But, gentlemen, what do you think?

Mr. LOGSDON. Let me take a try at a response to that. I think in discussing whether we go ahead with the station, instead of asking what the station is for, it would be better off to step back with the longer term perspective that you're suggesting, Mr. Perkins and say, what are we in space for?

Mr. PERKINS. Yeah, I think you're right.

Mr. LOGSDON. What do we want out of the space program? We want some economic benefits. We want some societal benefits in management of this planet. We want a sense of vision, of future, that matches our national self image. Ultimately we want, I believe as a people and indeed, as perhaps a species, the ability to be other places in this solar system. We want a lot of things out of our space program, and it's a really long term enterprise that we're in the pre-adolescent phase of.

All right, if you sort that out and you say, yeah, in my judgement that's the kind of future I want my children, my grandchildren to have and it is that kind of long term enterprise, and then you say, do you need a permanent facility in space to accomplish a reasonable number of those things, and I think the answer to that is yes.

I think you've got to reason back to—it has become a cliche, but the station is indeed a logical step towards almost every pathway you would like to go in the development of space, and if you—I think you need to accept almost on faith that those sorts of things are things that this species wants to do. If you set those as assumptions, then I think you can reason very logically back to having people in space on a permanent basis is the way to do it.

Mr. PERKINS. One just additional question and concern that I have. If, you know, following the goal of going to the moon. We saw probably the space surge seem to dissipate across this country. The problem with a goal sometimes is that once you achieve that, everyone says well, now we've done it and we sit there for a while.

Do we need in terms of an intermediate goal, not just a goal of going to Mars with man because that will be done eventually, in some time perspective, but a goal that is kind of self sustaining; an ability to have more settlement, a very close one, on a timetable very close to the actual going to Mars, so that we don't lose that drive and fall back as we did after Apollo.

Mr. HESSER. I'd like to comment on that. I was a young engineer at the time of the Apollo program. Fortunately my children were a lot younger than they are now, and they weren't at the point where they were choosing careers themselves.

I saw a lot of my contemporaries laid off at the conclusion of that goal, and a lot of the space industry talent just disappeared. It is unfortunate that that goal didn't sustain a permanence in the country's space program. It basically caused a lot of us to go scurrying around looking for different types of work.

It took me more than 6 years to prepare myself for the job that I was asked to do in the space program—formal training. And that's one of the things that ASME has in its purpose, to educate our technical population for the development of things that will help us to keep our prominence in the world in advancing technology.

When we have a goal that everybody knows is going to always be there, then we don't worry so much when the Government finds it necessary to cut back the budget a little bit, because they know it will always be there.

If they decide to build a Space Station, and that is one of our national goals, and they find that for one reason or another that there isn't enough money now, then the space station can either be wiped out—that's the way it is now, or if we have a policy in place, then that date can be changed as to when that goal can—is going to be attained. You can reach the goal by changing the date that that goal will be obtained, and still not cause panic amongst the industry, and that's what you have now. You've got a lot of people that are very, very concerned.

Mr. PERKINS. I won't take any more time, Mr. Chairman. I thank you for your——

Mr. NELSON. Well, I appreciate your line of questioning. You're trying to get at what we really need to be doing.

Mr. PERKINS. Yes——

Mr. NELSON. That is getting the big picture. Not getting bogged down in this or that issue, trying to move the institutional biases of this country onward, so that we can get on with a Space Station—get on with a space program where we need to be going.

Mr. PERKINS. Yes, and in that regard, gentlemen, I think that one of the things that you can do best indeed, because the imagination is out there across America, across the world, there's no question about that.

But trying to channel that imagination is something else, and trying to get a conduit that we can use here as policy makers to channel that imagination is something that we're looking to you for, trying to find what conduits you have for us, and you know, in my own mind I'm not yet hearing enough that gives us that big picture that the Chairman is referring to.

Mr. HART. Mr. Chairman, if I could——

Mr. NELSON. I'm sorry, go ahead.

Mr. HART. If I could reemphasize a point that Dr. Flajser made early in our testimony about this role of national leadership in the space program. Certainly all the budgetary problems are always before us and have to be addressed in any program. But, had we put them at the priority we're discussing today back in 1961, the likelihood is we never would have gone to the Moon because you really couldn't develop any kind of economic justification for it.

Mr. NELSON. Sure.

Mr. HART. Yet we put the Space Shuttle program forward on an economic justification.

Mr. NELSON. True.

Mr. HART. And then ended up with trouble. So I think what's needed here really is a bold leadership to set out goals and not to feel as though they have to be economically justifiable. Certainly an international manned mission to Mars would be an excellent

use of the Space Station as a point of departure. Thinking like that based on the taking of the explorer approach rather than the financial approach to our mission planning.

Mr. NELSON. Mr. Woodcock——

Mr. WOODCOCK. Wait a minute, Mr. Chairman, it is very——

Mr. NELSON. Just one second. I wanted to point out that one of the things you had said earlier was an example. When you were talking about when the Space Shuttle was conceived, that it did a lot of things later on that we never could have thought of. One of the things it did was something that Mr. Hart did with it.

Here we had this satellite out there, Solar Max. We tried to go repair it. Pinky Nelson goes out there to capture it. It's not built like we thought it was according to the design. Then they had to get out there and Terry had to capture it with the arm, and then they repaired it, and that was quite a drama. So too, there are so many things in the future that we can't plan for, that we need to move on.

Mr. WOODCOCK. We really need to look at space as a frontier, and not as a place to go and visit and come back home again, because as long as we look at it as a place to visit, and come back home again, we'll be stuck with the Apollo problem.

Well, okay we've done that. What's next? But it is a frontier, and it's a frontier actually without end, although there—and that's the way we need to look at it, is really as a frontier for both for exploration and for economic development.

Mr. NELSON. John Glenn, in his 25th anniversary speech said that we need to get out of the sprint mentality and get into the marathon mentality with the space program.

Mr. Nagle and then Mr. Packard.

Mr. NAGLE. I have a—Mr.—is it Hesser?

Mr. HESSER. Yes.

Mr. NAGLE. One question for you, and then one question for the panel if I can.

In your testimony on page 2 you stated that we seriously doubt if "the fourth orbiter fleet will be able to accomplish all of the above missions" and then you go on to recommend a fifth orbiter. On page 6 of your testimony you said, and I quote, "we are appalled that NASA has not provided for ELVs in the FY88 budget. With the crippled Shuttle program there is no way this country can launch the required military and commercial of the next few years without ELVs." I guess, given the budgetary constraints with which we have to work, if you have to choose between ELVs and a fifth orbiter, which are you recommending to the Committee that we do?

Mr. HESSER. If I had to choose between ELVs and a fifth orbiter?

Mr. NAGLE. Yes, sir. That may be the choice we have to make.

Mr. HESSER. Well, Congressman, we're not standing here before you, you know, suggesting where you're going to get the money. We know that right now we've gotten zero orbiters on line. If you don't have——

Mr. NAGLE. Mr. Hesser, I'm not asking you to tell us where we get the money. That is our responsibility. I'm asking you if we have budgetary constraints and limitations, and we have enough money

for a fifth orbiter or we have enough money for some ELVs, which are you recommending that we pursue?

Mr. HESSER. I would say a fifth orbiter would not be as high on the priority list as ELV's.

Mr. NAGLE. Okay. Thank you. Then for all of the panel, I'd like to ask a question that is puzzling to me as a new member. As I've said, and I'll say even in the Chairman's absence, thanks to his help I'm on this Committee, and I wanted to be on this Committee because I believe in the future that this Committee represents.

But one of the puzzling things to a new member is—is that, it's hard in reading your testimony to decide which priorities you are emphasizing, which ones you would wish to emphasize. I mean, for me is the MILSTAR more important than the TDRS? Is the Mars Observer more important than the Galileo project or the Magellan, or the rest of them?

And so, in looking through your testimony and seeing the various recommendations that you've made to us of programs that you think we should fund, do you have any sense of priority in terms of the direction this Committee should go, given our budgetary constraints? And I don't mean to just to direct that to you, Mr. Hesser, but the entire panel.

Mr. HESSER. Well, it's hard to have a priority if you don't have a policy. And I think that's what we're all trying to get to.

Mr. NAGLE. I don't want to pick on you.

Mr. Hart, do you have anything to say?

Mr. HART. Well, being from the manned space flight school, I guess I would not do justice to my colleagues if I didn't vote for a fifth orbiter. But, you know personally, I feel that it was a mistake in the early 1970s, again getting back to the economic justification of the shuttle program, to cancel the expendables. Certainly it's proven that way. Everyone agrees.

Again, economics just can't be the highest priority in something as much on the leading edge of technology as the space program. We have to be able to invest in the explorer part of us more than the economic part of us, and—but I would have to say from my personal view that the ELVs are needed now more than a fifth orbiter.

Mr. NAGLE. Thank you very much for that comment. I understand your loyalties. I didn't mean to limit it, however, to just simply the fifth orbiter versus ELVs. I mean just in terms of projects, in terms of Mars, or in terms of the Galileo and the Magellan and any of the rest of them, is there any sense on the Committee—or in your group, in terms of where our priorities should be?

Mr. HESSER. Mr. Nagle, let me give you some sense of why a group like this is going to have a hard time responding to that question. All of us have testified today, and in the past that we believe that the program has been grossly underfunded for two decades and——

Mr. NAGLE. I'm a first termer. That's not my fault. [Laughter.]

Mr. HESSER. But you have to deal with what your predecessors have left you, and so essentially all the water has been squeezed out of the sponge, if you will. It's very difficult to say what our priorities in what is much less than we should be doing, anyway. I

think the problem all of us have is that we're all here telling you as you would expect us to, given where we come from, more is better, and that's not the world that you live in. You have to struggle for every dollar for this program. I don't think it's reasonable for us to say Mission X is better than Mission Y. They're different.

Mr. NAGLE. But if you don't, who is going to?

Mr. HESSER. You.

Mr. NAGLE. But on what basis? On the basis of our own feelings that Mars is more interesting than Jupiter?

Mr. HESSER. It's probably as good a basis for choosing between those two as anything else. There's no technical reason I can tell you one is better than the other.

Mr. NAGLE. Well, would you agree that if we do develop a national policy on space, one of the things that national policy ought to do is not only give us objectives and goals, but also give us some sense of priority as to which steps to accomplish, and in what kind of a sequential order.

Mr. HESSER. Indeed. I mean part of the problem is we don't have a framework within which to make those choices.

Mr. NAGLE. Finally a question that may be out of your area, but obviously there's been a lot of rescheduling of the projects that have been pushed back because of the Shuttle failure.

I mean this only as a generic question. Any thoughts you would care to share with us about your own perceptions of that rescheduling, in terms of the ones that have been dropped, the ones that have been pushed back, the ones that have been moved up?

Mr. LOGSDON. Well, we clearly have testified—I think everybody here but we AIAAs specifically—that pushing back Mars observers to 1992 has all kinds of ripple effects that are not desirable. If in fact as seems to be emerging in NASA's internal discussions, a Mars focus is the vision that they end up offering to the country and to the Committee, and a focus on international collaboration—then phasing that Mars mission with the Soviet mission in 1988, with a potential joint mission in the mid-1990s, that 1990 launch date gets to be very important. So there is an area where we specifically disagree with the schedule, the manifest as it now stands.

Mr. FLAJSER. Just an amplifying comment. In our statement, it's unclear that the current shuttle manifest, as deficient as it may be for various missions, will even be the one that holds. The situation could easily get worse. I think what I heard all of us essentially saying is that you have to purchase to the extent you're able, backup ELV capability for a lot of missions to keep the broader manifest, if you will, going.

Mr. NAGLE. First, you know, the problem we run into on that is, is that if you purchase ELV's, when you go ahead with the development of the heavy lift launch vehicle, you're 4 years down the road before any of those are available. I think a Titan IV has been talked about. Now a Titan IV takes 4 years between the time that we order it is available to use. Then we're back—we're in 1991 already anyway. If we commit the money and then, you know, there aren't significant shuttle slippages or delays, then maybe we have those ELVs and don't need them. I don't know the answer to that today, but that, from our perception, for my Committee members, that's one of the problems that we're running into. Thank you.

Mr. NELSON. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman. In respect to what my colleague, Mr. Perkins from Kentucky said regarding long range goals, I certainly concur with that.

We missed the mark in our Science Policy Task Force last year, I think, because we did not achieve that, not just in space. I certainly hope that in this next year, or next 2 years we will make better progress in terms of reaching some specific goals in space and biomedical and agriresearch, in energy research, and certainly in aeronautical research. This Committee has a responsibility that we haven't filled yet, and I am certainly hoping that we will. I certainly intend to be a part of that process.

In regard to the shortage of funds, that's a given. I don't think that we're going to be able to solve our problems simply by increasing the funding for our various programs. There are several things we could do, I think, and I'd like your opinion as to how well we're doing them in NASA and in other agencies that are involved with the projects that we're talking about.

One of course is, we can prioritize or reprioritize and eliminate or cut back on certain projects in order to strengthen others. Another way is to, of course, become more efficient. Do what we're doing, but do it more effectively and more efficiently, and thus stretch our dollars further.

Certainly another would be to reevaluate our commercial processes and see if we can't actually generate additional revenue with our programs as they now exist. Someone mentioned, used the term that I thought appropriately demonstrated or described that process, and that is to become competitive or by competitively exploiting our programs as the private sector would do.

I'd like your opinion as to what we can do in some of these areas to stretch our dollars, to reprioritize, or to commercialize some of our programs better and increase and generate revenue. Are we doing all we can do in those areas? What can we do that would better stretch the dollars?

Well, let me ask everybody specifically. Are we operating in our various programs as efficiently as we should?

Mr. FLAJSER. If you ask the question of efficiency I think you heard something here that perhaps we can come back to, and that is there are gross inefficiencies in the system if you start and stop.

If you don't commit to certain things, you disband certain teams, whether they be university teams, industrial teams, whatever. You delay missions. You put them off because in the short term you can solve a budget problem. In the long term, it becomes a very inefficient proposition. But, the realities were that you had to make those choices.

So there are inefficiencies always built in the system when you can't optimize the schedule for building or succeeding in the particular mission. If you were to delay a program such as Space Station, or if you were to stop it and then revisit it a couple of years from now, you know you've lost a tremendous capability, and a lot of money went, not necessarily down the hole, but to put on the shelf it's not——

Mr. PACKARD. Not an efficient way of doing it.

Mr. FLAJSER. That's right.

Mr. PACKARD. Going to another point on the same subject. Are we doing all that we can do in terms of generating revenue from within the programs?

Mr. WOODCOCK. Well I think that perhaps I mentioned this before, but one of the things that needs to be looked at in the ELV context is whether NASA should be buying ELVs or buying launch services from a commercial industry that is in the ELV business, and how the funding would spread in those 2 cases. We need a commercial ELV industry in this country, and they aren't going to be able to make it if all they've got is the commercial buyers of satellite launches. The market is too fragmented. They are going to need a little bit of support on the Government side. I know they're getting it from the DOD side on using commercial, or commercializable ELV's. I think that's one thing.

The other thing is that we are going to have to learn to be more productive in the aerospace industry in this country because if we don't, others will.

Mr. PACKARD. I won't take more time.

Mr. NELSON. Okay. Well, just wrap up here. Let me—Oh, I'm sorry. Mr. Walker.

And without objection, your opening statement is a part of the record.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS OF
REPRESENTATIVE ROBERT S. WALKER
MARCH 10, 1987

Good afternoon, Mr. Chairman. I would like to join you in welcoming our witnesses here today. I think that it is particularly important to have outside witnesses at this time, since we are rapidly nearing the point when we must make basic decisions concerning important programs, such as the proposed space station, and we need to hear from people who are not part of the NASA bureauracy.

This is a tough year for NASA. We are still in the midst of the recovery process from the Challenger accident, and the budgetary pressures are substantial. As a result of the need to adequately fund the redesign of the solid rocket booster, and the manhy other activities mandated by the Rogers Commisssion, and by this Committee, NASA has a lengthy and very expensive agenda to be completed before the next flight of the space shuttle.

We want to be sure that we provide the Administrator with adequate resources to accomplish that agenda, but we also want to be assured that we do not denegrate other areas of NASA in that process. We have already seen a number of indications that lead us to believe that space science is already feeling the budgetary pinch.

Only a few days ago we heard from the Office of Space Station. I must say that the press reports of that hearing caught the correct message. The headlines that indicated

that this Committee was attempting to tell NASA that the space station is in deep, deep trouble were exactly on point. This Committee, and the Congress, expect to have NASA fully explain exactly what the mission of a space station will be, and we expect to have that mission justified to a point where a reasonable man would say that this project makes so much sense that the only reasonable course is to go forward. They not only have not done that yet, they have not even started to define the mission, or to provide any real justification. As I told the NASA witnesses, to date I have not seen sufficient justification for an eight billion dollar station, let alone a twenty-one billion dollar undertaking. Since we have only a few short weeks before this Subcommittee must mark-up the Fiscal Year 1988 NASA Authorization bill, I am now looking for alternative approaches that make sense.

I hope that these outside witnesses will be able to help us face these tough decisions with a new perspective. I know that there is not a single member of this Subcommittee who is not totally in support of our civil space program, but we are all charged by our constituents to ask tough questions, and make many tough decisions concerning the allocation of scarce financial resources. In those cases where we do not get adequate answers from the administration, we have to seek the best advice we can find outside the government, and then we have to set funding and policy based on the information available.

With that on the record, let me again thank our witnesses for their help, and let us hear what they have to say.

Mr. WALKER. Thank you Mr. Chairman. The one thing I noticed in just glancing through the reports and so on. I mean, we all seem generally agreed that what we need to be doing is spending more money on space.

Let me ask you this. Would it be rational in your point of view that if we really wanted to achieve the goals, whether it be long term goals, short term goals, that what this Nation should be shooting for is spending 2 percent of gross national product on space? On exploiting the space frontier? Is that a——

Mr. LOGSDON. That would be wonderful.

Mr. WILSON. Our surveys of our members, and of course, we have a highly supportive group of citizens for the space program, think that those numbers are well within what we ought to be doing.

Mr. WALKER. Two percent would get us about $80 billion a year at the present time. That would be a number that would be a reasonable number if we really wanted to be moving forward?

Mr. LOGSDON. Mr. Walker, I may be getting myself in trouble, but I don't think so, with the organization I represent. I don't think that the capability to use that amount of resources well now exists. That may be something that in equivalent terms you want to build up to, but that—and strange coming from you, knowing your background, is really throwing money at a problem.

Mr. WALKER. Okay. Well—but I'm going to go on here in a minute. We're spending about 40 right now. We're spending somewhere in the vicinity of 30-40 right now, so what—I hear you're saying—excuse me?

Mr. PERKINS. Counting DOD?

Mr. WALKER. DOD plus what the commercial sector is already—is putting in. We've got about a $10 billion a year commercial sector out there at the present time. And so, if you—you know, I'm talking—I'm talking GNP here, I'm talking national resources. I'm not suggesting we're going to have a NASA budget over $80 billion a year, by any stretch of the imagination, but if you include it all, we're talking about $40 billion a year that's already going in.

Now as to what I'm saying is—is here's a group that represents a broad base of folks. Are we saying that doubling the national effort would be a responsible direction to go at the present time?

Mr. LOGSDON. I think that you have to disaggregate that to have an intelligent answer. It seems to me that the DOD space program without considering SDI is pretty well funded.

Mr. WALKER. But how—how do you throw SDI out of it at the present time?

Mr. LOGSDON. Well——

Mr. WALKER. It may well be that SDI also represents a major ingredient for this Nation's space. This isn't the Committee to discuss SDI. It may well be that some of the things that we would develop for space with regard to SDI such as nuclear power reactors, that could supply a—large amounts of power in space that would have tremendous commercial applications, is something that we want to consider as a part of all of this.

Mr. LOGSDON. Sure.

Mr. WALKER. You know, a Space Station that doesn't have to rely upon solar dynamics or solar collectors for its power but rather could get power from a microwave to it from a nuclear reac-

tor someplace in orbit all of a sudden has the kind of power aboard it to do a lot of commercial applications that are not going to be available to it in this original design. We are not likely to see that reactor developed by NASA. We're not likely to see that reactor developed by the commercial sector at the present time. But, the one place they are developing that reactor, the SP-100, is in the military program.

Mr. LOGSDON. Mr. Walker, I just want to be clear and then yield the table to the other gentlemen here. I'm not—I wasn't really making a comment on the desirability or non-desirability of SDI.

Mr. WALKER. Okay.

Mr. LOGSDON. I think that you have to look at the Nation's space effort in different pieces, and say, are those pieces adequately funded? If you look at the funding curve for DOD over the past decade, the slope is up.

Mr. WALKER. Yes.

Mr. LOGSDON. If you look at the funding curve for the civilian program over the past 2 decades, it went down and stayed level.

Mr. WALKER. Yes.

Mr. LOGSDON. And that's where the shortfall, I think, really is.

Mr. WALKER. But let me suggest, and it goes along with what Mr. Perkins was talking about and so on, except I would take it one step further.

It seems to me that our problem around here is that the only place that we think that we define what goes on in space is here in this Committee room, or in the other Committee rooms around the Hill. But the only sense of space policy is here, and the problem is that what we have ended up with is exactly as you described it, kind of a segmented kind of policy. But, no one has really sat down and thought through that the space policy that we develop for this country ought to be an intrical policy, that ought to consider what's going on over in the Defense Department, and seeing whether or not applications from what they are doing that have implications for the civilian program.

Also, to take the civilian program and decide whether or not there are applications of that for defense or more importantly, for commercial. And that if you want to get to $80 billion a year, we're going to have to have a large degree of commercial on it. The reason why I raise all of that is because it seems to me that then the design of the Space Station does become somewhat important.

What we build for $21 billion we can't just build a station, and satisfy it. It seems to me that if you're going to build a station that ultimately attracts $80 billion worth of investment—or some percentage, not the full $80, but say $30 or $40 billion worth of investment—is a station that might be somewhat different than having a national laboratory flying around in space. That if in fact you're going to integrate that station with the Faget modules, for example, that need a man tended capability which obviously is going to be the station.

Well then you are talking more than simply a station. You're talking about an infrastructure you're going to build out there, and that the likelihood is that for the commercial community, that Fujay module has more adaptability for it, then maybe the Space Station does, because on the Faget module, they can decide what it

is they want to do. For a guy looking to go out and make some money, he is more likely to be attracted to that than to something where NASA has the final say in what they do.

Now, what I'd like to hear from you all is, when you get beyond the Committee room, is there anybody in the industries, is there anybody out there in the commercial sectors, is there anybody in the societies, who is thinking through space from that perspective?

Mr. WILSON. I could make this comment, Mr. Walker, about policy. I believe your committee picked this up last year when you urged that the National Aeronautics and Space Council be revived. As you may recall, that was in the original Space Act passed in 1958, and that was designed specifically to put the major government agencies in a policy-making posture for the whole space program, military and all. As you know, that Council was abolished in 1972. I don't think there exists today, even with the Senior Interagency Group on Space, an adequate mechanism for making overall space policy in this country.

Perhaps if your committee would persist in this matter again, you could revisit that question. It is the mechanisms that help you decide how you make your policy, and as I said, I think the existence of something like a council at the White House level would go a long ways toward trying to give you the way that you could work through the problem you are talking about.

Mr. WALKER. I appreciated the comment a minute ago about the ELVs. I think it is extremely important that if you are going to develop an industry that ultimately is going to have an impact, you cannot have government buying ELVs. You have got to have a commercial industry that sells launch services to government, and that, it seems to me, has an important role to play in creating the kind of economic climate that allows us to do a lot of things.

Mr. WOODCOCK. In the long run you would like to have that industry operating some kind of a second generation shuttle, but that industry isn't going to start by doing that. It has got to start with ELVs. You have got to have an industry there.

Mr. WALKER. Let me ask you this. I didn't hear any of you comment and I didn't see anything in your testimony about aerospace plane. Isn't it absolutely essential to our space future that we lower the cost to orbit by several magnitudes? Doesn't aerospace plane play an important role in all of that?

Mr. HIEATT. Potentially it has——

Mr. WOODCOCK. It is one of two or three options that has that potential. We shouldn't bet on only one option but we certainly should bet on that one as one of the options. If you look at the ultimate potential for reducing costs, there is about two orders of magnitude in there somehow but it is going to require a bootstrap process. You will never get it at today's traffic rates.

Mr. WALKER. But isn't the advantage of the aerospace plane over the other options that are available to us, which I agree would lower the cost to orbit, but the idea that the aerospace plane also has a dual purpose mission that it can fly, essentially as a hypersonic aircraft, and thereby give it some commercial value beyond going to orbit? Isn't that something we have got to focus on as a nation as well?

Mr. WOODCOCK. Yes, I think we certainly have to focus on that. I think the orbital marketplace may one day be as big.

Mr. WALKER. Yes, but the orbital marketplace can certainly be exploited by people who have such a craft available to them. But if you can't convince somebody to buy the craft in the first place, it becomes awfully hard. If you are talking simply about government, again, let me tell you the problem that this committee faces, and this is where I am coming to as well.

We see budgets projected out where we may not have more in the civilian program than $10 billion a year to spend for the next five or six years. Now, as I read through your statements here, there is no way that we can do the things you think are necessary on $10 billion a year. So we had better figure out a way to do some things as a nation that don't necessarily demand that the dollars all come through the Congress because regardless of what this subcommittee might want to do, the fact is that Congress is probably not going to expand that figure very much.

Oh, they might eke it up to $12 billion, but you are not talking about the kinds of bucks that will allow us to do everything, and we had better figure out some other alternatives. So what I am suggesting on this aerospace plane is if you can prove a technology and you can get a consortium of airlines to buy that billion dollar craft, that gives us a national capability that was not necessarily then purchased by government.

It is a capability not unlike having a fleet of 747's available to us if we need them for the nation, and from my opinion, we have got to begin to think in some of those terms.

Comment?

Mr. WOODCOCK. Yes, I agree with that, but I think that we shouldn't bet on that as our sole option for the technology for low cost access. That is all I am saying. The other comment is that we think, and I guess we tend to be far-out thinkers in the L-5 Society, that in the long range there will be commercial potential in developing the resources of the Moon, and yes, we thoroughly believe that there has got to be a commercial sector involvement. If we are going to be really successful in space in this country with our overall attitudes and our still frontier culture, there has got to be a buck in it somewhere.

Mr. WALKER. Yes. Our policy with regard to the Moon was dumb. We should have a permanent colony on the Moon right now. We had the capability in the early seventies with the technology we had there with the development of a space tug as the only thing that we would have needed. We could have easily been colonizing the Moon right now, and you could, in fact, be exploiting that for some very important commercial resources right now.

For instance, I have said to some jewelers, what if we found gem stone quality rocks on the Moon that we could bring back just a few of them that could be cut, what would they be worth? Every one of them has told me they would be worth far more than any diamond that you could possibly come up with. You know, there is almost the settler gold rush quality involved in that kind of exploitation. That is nothing NASA is ever going to do, but the fact is that there are some real potentials out there that have yet to be

exploited. We made some gross errors in the early seventies when we didn't exploit those opportunities.

Mr. LOGSDON. Mr. Walker, just one final comment. You have this long-term vision of engaging the economic enterprise of this country in space as the way to eventually get it on a solid basis, and I think all of us agree on that. But if the country is limited to $10 billion in space for the next five years, for example, it just moves that frontier further and further out. There is a disjoint between the short term and the long term.

Mr. WALKER. Yes, and I guess what we need to do is think through how you martial those resources because at that point it becomes a very difficult question. That is the reason why some of us, when we see that $21 billion figure for the Space Station, begin to say, my goodness, where are we going to find the resources, we obviously can't do it in a $10 billion budget.

Mr. LOGSDON. And do anything else.

Mr. WALKER. And do anything else. We can't even fly the Shuttle with that. You are going to do no science. There would be doing nothing going on. That obviously is unacceptable as a program, too.

Mr. FLAJSER. Mr. Walker, just speaking personally now, with a $10 billion space program on the civilian side, I am not sure you are going to attract private capital to come in and open up a lot of the opportunities I think you want to open up. There is so much risk, such a long-term nature in a lot of these ventures, and you know a lot about the problems. You have been worrying the problems for many a year.

But when you have a situation where there is a space transportation system that is somewhat unreliable both in terms of schedule and cost, you have a problem with insurance. You have a problem where the government enters into a contract with a private entity called EOSAT, and then for budgetary reasons backs out. You begin to realize from a private sector point of view that the government may not be a very good business partner. Certainly not very reliable.

The kinds of investments you are talking about are in the megabucks. They are not a million here and a million there. So you essentially depend on the government for the seed corn. You depend on the government to develop the ACTS program. You depend on the government to provide materials, processing R&D capabilities so that you get to a point where maybe someone is willing to risk $5 million to $10 million.

You can't depend on the commercial ELV business if there is no customer really other than the government to use it. I mean you are looking for commercial payloads as well as government payloads.

So I agree with you that if you are going to be limited to $10 billion you have to look for other ways of finding that investment. But, speaking, again, personally, I'm not sure the private sector is going to be the source for a lot of that capital. The risks are too high.

Mr. WALKER. It is certainly not going to be if we don't design with them in mind.

Mr. FLAJSER. That is right.

Mr. WALKER. You know, if we are building the kinds of things in terms of infrastructure that don't even take the commercial into account, you are absolutely right. I guess my concern is that as we are spending this money, that we spend it in ways that understand that we are going to have to look beyond the government to get the money. I see the linkage. The linkage is very, very important. You can't have one without the other. But I am also concerned that we may proceed on programs that assure that we never get the other part, and that we have gone down that road before and could very easily do it again.

Thank you, Mr. Chairman.

Mr. NELSON. Let's try to think together big thoughts as we plan where the program should go. In the long range, I want you to help us articulate, should the long-range goal be Mars, should it be a lunar base? What happens if we were to get a joint mission going with the Soviets looking to the next century to go to Mars, and then what happens if they back out? What happens if they back out and go to the Moon? Where does that leave us?

Somehow we need to come up with these ideas and articulate a goal and then try to move heaven and Earth to get a White House, a president, either this one or a future one, to say this is what we are going to do, now let's go do it.

One of you talked about the practical politics that it would go beyond a president's two terms and that would be difficult, so somehow we have got to be most articulate in how we are going to state what this goal is.

Now, in the immediate, as we are getting ready to go to markup on the 31st, I am going to make a recommendation to this committee that we go $255 million over and above the NASA request of $9.5 billion, and it is going to include those three ELV's at $100 million, it is going to include $10 million for a high resolution solar observatory, $75 million for ACTS, $50 million for Mars Observer for the spacecraft, and $20 million for second sourcing on the SRB's.

So any disagreement with that recommendation?

Mr. WOODCOCK. No.

Mr. HESSER. None.

Mr. FLAJSER. What do you do with the rest of the budget?

Mr. NELSON. Well, we are going to massage the rest of the budget, and of course, a big item in there is $767 million for the Space Station. We have got to have some answers, and the clock is ticking.

Gentlemen, it has been stimulating and we appreciate you sharing with us today. Thank you very much for your contributions.

May I encourage you to think about that big picture and to start pressing your friends in government and out of government, in the industry and out of the industry, about what we need to do for the future of this country. That is the way. If we start getting a little insistent about formulating these goals, then I think it might start moving the system.

Thank you, and good afternoon.

[Whereupon, at 4:47 p.m. the hearing was concluded.]

# 1988 NASA AUTHORIZATION

WEDNESDAY, MARCH 11, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 1:10 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good afternoon. Today we are going to continue the hearings on the fiscal year 1988 budget. Today we are going to have testimony concerning the commercial side of the House.

This committee certainly has supported the commercial use of space and the commercialization of government systems. Despite this policy support, certainly we can recognize that the *Challenger* accident has deterred efforts to move along in the march towards our expectations for the commercialization of space.

The impact of the administration's cancellation of NASA's commercial launch role has yet to be fully understood, and perhaps that is something that we can take up today and learn more about the effect of the policy on the condition of the United States communications industry.

Now, for unique commercial payloads, the Shuttle will continue to fly them, and industry continues to face, certainly, throughout all of this, the problems of high cost and risk and the troublesome absence of assured flight opportunities. But if there is any silver lining to this cloud, perhaps it is in the development of a commercial launch industry as an important complement in the mixed fleet philosophy that now is essential and everybody realizes that it is essential to have assured access to space.

So we look forward, hopefully, to the emergence of this industry, and today we want to understand better what the administration and Congress can do better to foster its creation.

It is probably because of the farsightedness of Air Force Secretary Pete Aldridge in his drawing of the RFP for the Medium Launch Vehicle that indeed was the main recognition by the National Space Club in deciding to award him the Goddard Trophy for this year's Goddard dinner.

I am very hopeful, with what I see coming out of that resulting competition and its award, that there will be a viable commercial launcher that will be viable in its competitiveness with launchers around the world, and indeed, we have been told that also for larger commercial payloads, that Martin Marietta has intended to go ahead and commercialize the Titan 34-D.

So we are pleased to have with us Mr. Gillam, who is the Assistant Administrator of the Office of Commercial Programs. We are happy to have Courtney Stadd, who is the new Director of the Commercial Space Transportation Office in DOT, and we are happy to have Bob Brumley, who will discuss the activities of the Department of Commerce in the space arena.

So we welcome you today and look forward to having you and your testimony, and we will have Bob Walker's opening statement inserted as a part of the record.

Now, let me tell all of you this. We have your written testimony. We don't want you to sit there and read it to us. That we have already taken care of. What we want you to do is just talk to us. Talk to us about your programs, talk to us about, in your case, the budget request, in the case of the Department of Transportation, likewise the budget request.

Mr. Gillam.

**STATEMENT OF ISAAC T. GILLAM IV, ASSISTANT ADMINISTRATOR FOR OFFICE OF COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Mr. GILLAM. Thank you, Mr. Chairman.

I was going to ask could I have my written testimony submitted for the record and to proceed with an oral statement, but you have taken care of that for me.

Mr. Chairman and distinguished members of the subcommittee, I wish to thank the subcommittee for giving me the opportunity to appear before you today in support of the NASA fiscal year 1988 commercial space budget. This has been an important year, as has each of our two years of existence been for the commercial development of space.

For us it has been a year in which we have explored many new avenues to make the program successful in view of relatively adverse circumstances and to find new ways to help space and space-related business development.

It also is important to note, Mr. Chairman, that in the competitiveness initiative submitted by the President to the Congress, there is a startling parallel between some of the initiatives that he proposed and some of the activities that we have already under way and some of the activities that we have already planned.

The technology share aspect of that initiative that refers to applied research with consortia of U.S. firms and universities fits in with our program of Centers for Commercial Development of Space, in our program of joint agreements such as JEAs and IGIs, and it fits in with the goals and objectives of our Technology Utilization Program.

The initiative associated with people-to-people exchange is in a way related to our Technical Exchange Agreements and our Industrial Guest Investigator agreements. The royalty sharing provision of that is consistent with the Federal Technology Transfer Act of 1986, and our agency through our Technology Utilization Program is implementing that activity.

Finally, his initiative associated with Federal agencies and laboratories seeking out science entrepreneurs is consistent with the new program or an experimental program that we have been working with JPL on. The program is called the RIMTECH Program. I will talk a little bit more about that later.

With respect to the Centers for Commercial Development of Space, it has been an exciting year for the CCDS Program. We have added four new CCDS' since our last testimony, bringing our total to nine. We are currently in the process of soliciting for our third round of CCDS'. The proposals are due in the end of April of this year. The selections are expected to be made in the July timeframe of this year.

If nine does not sound like a big number of Centers for Commercial Development, Mr. Chairman, consider that in the nine Centers for Commercial Development, there are 58 private companies involved, 22 universities, and six other Government agencies, including State and local governments.

The numbers are not as important as some of the things that are going on, and I want to assure you that there are important things that are going on at our Centers for Commercial Development. The recently announced technological breakthrough associated with superconductivity, our Centers for Commercial Development were contributors to that breakthrough. Our Center at the University of Alabama-Huntsville and the Center at the University of Houston both played a role in accomplishing that breakthrough.

There are many who talk about the importance of that breakthrough. I am not a specialist in that area but I have heard some refer to it as equivalent to the discovery of the laser. I can't vouch for the validity of that statement, but we do think it is a breakthrough of the first magnitude.

In the area of agreements, we have been working, as you know, for several years on trying to get the time that it takes to complete agreements down to 6 months or less period of time. We have done a lot of work in that area over the past year. We have modified our program. We have revamped our approach to agreements, and we have even published a manual which we call the JEA Cookbook. It is how to draft a JEA if you are from the private sector.

We have signed ten agreements over the last 12 months, and we still have 16 agreements that are pending. We have in the past 12 months done several agreements which we would like to classify as first-of-a-kind agreements. For example, last September we signed an agreement with a manufacturer of a privately developed ELV to launch using a NASA range, the Wallops Range. That agreement was signed with Space Services, Inc. for the launch of the Conestoga vehicle from Wallops.

Mr. NELSON. That is within the last year?

Mr. GILLAM. That was last September.

Mr. NELSON. How many other JEA's have you signed in the last year?

Mr. GILLAM. JEA's?

Mr. NELSON. Yes.

Mr. GILLAM. I would have to look up the precise number, but of JEA's there were probably about five that we signed in the last year.

More recently we completed action on an agreement that we sent up to the Congress in the last October timeframe, which was the transferring authorization to use NASA tools, facilities and equipment for the Atlas Centaur vehicle with General Dynamics. We received the end of last month the final concurrence from the final congressional committee, and that agreement will finally be approved by the Administrator either today or tomorrow.

Finally, a first-of-a-kind type of agreement that we signed in the last 12 months. In December we signed a long-term research agreement with 3M which was a joint endeavor agreement of sorts. It was an agreement which called for a term of approximately 10 to 12 years, and it called for 62 flight experiment opportunities to be provided under the terms of that agreement.

In the Technology Utilization Program, we have also had several firsts this year. In late 1986 the first implant of what we called the Programmable Implantable Medication System was performed at Johns Hopkins University.

Mr. NELSON. When was that?

Mr. GILLAM. December 1986. Since that first implant, there have been three implants in diabetics of the device, which is a metered, time-calculated insulin dispenser in the case of the diabetics. It can be used in dispensing other medicine.

The RIMTECH concept that I mentioned earlier stands for Research Institute for the Management of Technology. It is composed of Southern California high technology entrepreneurial companies, and an agreement with JPL which allows these companies to tap JPL for new product development technology.

There are seven companies currently in the RIMTECH association, but by the end of 1987, we expect to have as many as 30 companies involved in the RIMTECH activities. The companies must have an annual sales of less than $250 million, so the RIMTECH proposal is one for small companies. They pay a fee to belong to the association of $25,000 per year, and they draw down against that $25,000 as they use the capability of the technology that is made available to them by JPL.

We have a larger program called the Technology Affiliates Program, which is for large companies, and the planning and the implementation process are completed on that technology affiliates program. So we have one for small companies, RIMTECH, and Technology Affiliates for large companies. JPL will be making an announcement on the Technology Affiliates program in the very near future.

We are expanding both the RIMTECH programs and the Technology Affiliates programs to all of the NASA installations. We looked at it on an experimental basis at JPL. It has worked out very, very well and has been reasonably successful, to the point that we are now working on plans for spreading that to all of our NASA field installations.

In particular, one Industrial Applications Center, the one at the University of Southern California, has formed an association with State-sponsored organizations engaged in industrial and economic development in eleven western states. The concept is to establish satellite Industrial Applications Centers within these states, and they will be called NASA Industrial Applications Center affiliates.

They will also be able to tap the NASA technology data base to help businesses develop new products within those States.

The States include Washington, Idaho, Utah, Colorado, Oregon, Hawaii, Wyoming, Arizona, Nebraska, and Alaska. If that concept works out well, we will extend that concept to all of our Industrial Applications Centers and cover all 50 States.

There is also an agreement with that western region that will allow the USC Industrial Applications Center to not only tap into the data base of the NASA technology, but an agreement has been worked between the USC-NIAC and all the Federal laboratories, so that now the USC-NIAC can tap the technological capability of all of the Federal laboratories in the western region and not just NASA.

That is another activity that we have underway to expand the NASA concept throughout the Federal laboratory consortium.

There are many other programs, Mr. Chairman, that I could mention in Technology Utilization that we have under way, but I will be brief and just make a brief statement concerning our SBIR Program. In 1986, in Phase I of our SBIR program, we received 1,624 proposals from small businesses. We awarded 172 awards out of the 1,624 proposals. In Phase II we received, in 1985 for example—we have not completed our 1986 Phase II program selections yet, but in 1985 we received 129 proposals from Phase I bidders that were wishing to go ahead into Phase II, and we made 85 awards.

So far this year, we have about 25 of the first graduates from the SBIR Program, and the graduates graduate at the end of Phase II, and Phase III is the commercial development. So that NASA steps out of the picture at the end of Phase II, and the commercial development of the items proceeds through venture capital or whatever means that they can to raise private funds to put the new product on the market.

Mr. NELSON. Why don't you give us an example?

Mr. GILLAM. I just happen to have one. The most—and we're not qualified to say this—but the one that we think that has the most commercial potential is one that was done at KSC, a small business, proposed that they develop an improved fire detection system for spacecraft assembly areas. One that would detect not only smoke but light and detect fires of materials such as liquid hydrogen, which doesn't give a clearly visable flame and it's difficult to see that it's burning.

This company proceeded through Phase I, which was the concept development phase, and Phase II, which was developing a prototype. The prototype of that fire detection system has worked out so well that the Kennedy Space Center is planning to install that in the high bay area of its Launch Equipment Test Facility, as a prototype fire detection system.

If that fire detection system works as well as we think it will work, that will be a very viable commercial product and will have applications throughout the country.

Mr. NELSON. And that started off in this—what's your acronym? SB——

Mr. GILLAM. Small Business Innovation Research Program. It was passed by the SBIR Act, I believe, of 1981. And it is a legisla-

tively mandated program, that 1.25 percent of the R&D dollars of all Federal agencies be spent with small businesses to do research and development that could lead to either improved R&D work if R&D is your mission, or to commercial products which could either be sold to the Government or on the commercial market.

Mr. NELSON. All right, take your Centers for Commercial Development and give us some examples of the work product there.

Mr. GILLAM. The product? The superconductivity product is the most prominent example of a product. In late January experimentation was run at the University of Alabama-Huntsville using a team concept with the University of Houston to try to achieve superconductivity at a higher temperature. As you know, superconductivity was discovered in 1911, but it was done at a temperature at around zero degrees Kelvin, which is about minus 450 degrees Fahrenheit. At minus 450 degrees Fahrenheit, the only medium that could be used, I believe, was liquid helium, but I'm not certain of the medium that could achieve such cold temperatures.

Through using various materials, in particular metal oxides, the University of Alabama-Huntsville was able to achieve a state of superconductivity at a temperature warm enough that the coolant that could be used was liquid nitrogen, thus making it much more economically feasible.

Now theoretically, if you had a doughnut—superconductivity means that the resistance in the system goes to zero. So if you induced a current into a doughnut that was superconductive, the current would flow forever. So it has tremendous electronic applications and other applications. And that's the most notable result that we've achieved from our centers.

There are lesser results, but those have been mostly done in groundwork. And the centers are focused on groundwork in preparation for flight, and as yet they've not had the opportunity to fly, which has prompted us to consider extending the time or the first few centers that we have selected from our original 5-year term of funding to a 7-year term of funding to really give them an opportunity to get flight results.

Mr. NELSON. All right, now your original concept was five years. And at the end of that five years they should have been what?

Mr. GILLAM. Self-sustaining.

Mr. NELSON. And describe that for us. What's your definition of self-sustaining?

Mr. GILLAM. Initially there is a requirement that there be private sector resources invested in the Centers for Commercial Development. On the average, the dollars have been leveraged in those selected about 1.75 to one. That is 1.75 private dollars to every dollar that the government is investing.

We made our commitment to assist them during the early years of their development so that eventually they could become self-sustaining using only private funds and no Government funds. But since the *Challenger* accident has impacted their opportunity to have access to space and their opportunity to do research in space, we're considering extending that 5-year period to a 7-year period simply because of the lack of the opportunity to do development work in space.

Mr. NELSON. Okay, now when you made reference then to the agreement earlier with SSI on Wallops Island. You were not—you were talking about a separate kind of agreement. It wasn't a JEA and it wasn't something that was coming out of one of the centers. This was a separate kind of agreement.

Mr. GILLAM. Correct. That was an agreement between NASA and SSI that allows SSI to use NASA launch facilities at Wallops, or that allows them to build their own launch facilities if they so desire, so that they can use Wallops as a launch range for launching the Conestoga vehicle, which is the small, privately developed, expendable system. So that is a capability use agreement on a commercial basis in accordance with the terms and conditions in the Commercial Space Launch Act. So you might call it a Commercial Space Launch Act agreement.

Mr. NELSON. Go ahead.

Mr. GILLAM. Mr. Chairman, I've finished my prepared statement and will be happy to answer your questions.

[The prepared statement of Mr. Gillam follows:]

Hold for Release Until
Presented by Witness
March 11, 1987

Statement of

Isaac T. Gillam IV
Assistant Administrator
Office of Commercial Programs
National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

The year that has passed has been a unique and challenging one for the Office of Commercial Programs (OCP). The Shuttle accident has required refocusing for all NASA programs and this office is no exception. There have, of course, been delays in certain portions of our program due to the lack of access to space. However, we are exploring alternative means of getting commercial development payloads to space.

The OCP budget request for FY 1988 is $54 million. The Commercial Use of Space Program is funded at $35.7 million, and the Technology Utilization Program budget is $18.3 million.

OCP's major refocusing in light of the Challenger accident and resulting lack of near-term flight opportunities is interweaving space and terrestrial commercial activities with regard to commercial outreach. Outreach is the identification and development of partnerships with U.S. companies that will enable them to assess prospects for profitable opportunities using space technology and/or the unique space environment. NASA's technology utilization and commercial development programs provide a sound core for the integration of this agency's private sector outreach effort.

Outreach:

This consolidated outreach program currently integrates five principal elements: the commercial outreach contractor (Boeing/Peat-Marwick); the NASA Industrial Applications Centers (IAC); the NASA Field Centers and their support contractors; the Centers for the Commercial Development of Space (CCDS); and the American Institute of Aeronautics and Astronautics. In addition, future planning includes integration of the NASA Centers of Excellence as a principal element of the outreach program activities. The outreach effort will provide access to NASA technical data bases, applications engineering programs, information on the availability of test equipment and facilities, space commercialization opportunities, and expert technical assistance. Agencywide commercial outreach planning is complete; implementation began in December 1986.

In FY 1988, NASA will utilize its existing dissemination center network to contact and acquaint U.S. industrial firms with opportunities to actively interact and participate with NASA in technology transfer and space commercialization. Such contacts are envisioned on a face-to-face basis, with appropriate follow-up including seminars, conferences, and workshops to explore more detailed characteristics of the "opportunities" for interaction. The NASA Industrial Applications Centers, which are nonprofit university-operated centers, are in a unique position to serve as NASA's surrogate in aligning U.S. industrial interests in space commercialization as well as opportunities for commercialization of advanced technologies resulting from NASA's R&D programs. The technological needs of industry -- and of NASA -- would benefit from this synergistic approach designed to bring engineering resources of both in closer proximity.

Commercial Use of Space Data Base:

The NASA OCP has developed for use with its outreach program a comprehensive commercial use of space data base, which contains all relevant literature on selected topics, and eliminates the need for multiple searches of other data bases or printed sources for information. The establishment of this data base

was one of the highest priority actions of OCP because it fulfilled an urgent need of the commercial space community. The data base became available through the New England Research Applications Center, a NASA IAC, in Storrs, Conn., in January 1987. It is also available to authorized users of the NASA/RECON interactive information retrieval system. Plans for further expansion of the availability of the data base are being formulated.

Using the data base, interested parties can locate information on a broad spectrum of space and space-related activities, including microgravity science and space processing; extraterrestrial resource exploitation; robotics/artificial intelligence in space manufacturing; levitation techniques; as well as space policy issues relating to the commercial use of space. Selective coverage is provided in the data base of private launch services; remote sensing; meteorology, telecommunications and power systems. Although 50 percent of the data base was extracted from existing NASA resources, the remainder represents the most complete and wide-ranging coverage of worldwide literature encompassing this broad subject area. The data base currently consists of approximately 9,000 items, most of which contain abstracts or summaries. It is now updated quarterly and is expected to grow at an estimated rate of 1,000 new items per year.

Cooperative Agreements:

When private sector interest has been stimulated through the use of the outreach and data base programs, NASA has five kinds of basic cooperative agreements, each designed to meet the requirements of specific types of private ventures: Joint Endeavor Agreements (JEA); Space System Development Agreements (SSDA); Technical Exchange Agreements (TEA); Industrial Guest Investigator Agreements (IGI); and Memoranda of Agreement/Understanding (MOA/MOU). To date, NASA has entered into 77 of these cooperative agreements with the private sector.

For many years, the NASA cooperative agreement process has produced a significant number of benefits for industry and the public. NASA and the private sector have, through such partnerships, developed an upgraded version of the

Delta vehicle; the Payload Assist Module for Delta (PAM-D) class missions; and the Transfer Orbit Stage (TOS). More recent agreements have been signed for other space capabilities and applications to be developed by the private sector such as the Industrial Space Facility, GEOSTAR, and SPACEHAB.

Several steps have been taken by OCP to cut JEA processing time to a more acceptable length. For example, NASA has prepared a "Joint Agreements Manual" which contains a "model" JEA. The manual explains the NASA policies reflected in the "model" JEA and describes the other types of agreements. While NASA recognizes that the "model" JEA language may not meet every proposer's special needs, the agency is willing to review justifiable special needs and negotiate mutually acceptable provisions within the context of existing policy and practice.

Another measure the office has taken in an effort to accelerate the approval process for JEA's is to fund flight integration within the OCP budget. Previously, other offices were required to fund OCP's payload integration through their own budgets. This extended approval time as each office exercised its right to review and comment.

Commercial R&D Enhancements:

The commercial R&D enhancement program reduces private sector space experiment costs by providing expanded government capabilities, i.e., hardware or facilities. NASA requires that private sector demand be demonstrated from more than one corporate entity. The inventory of space flight experiment equipment available to NASA and industry has been expanded significantly by cooperative agreements. For example, approximately 20 percent of existing microgravity flight experiment hardware has been developed through these cooperative agreements with the private sector.

Through coordination with various industrial sectors in FY 1988, the commercial R&D enhancement efforts will provide generic, multiuse research experimentation equipment. This equipment, as well as ground-based hardware, software, and analytical tools will be developed in order to expand the technical

research database on the commercial uses of space required by the private sector to help make economic decisions to commit to research and, potentially, manufacturing. Emphasis is placed on building the required technical infrastructure. The main thrust of the effort will be directed by the private sector in coordination with NASA. Resources will also be made available to obtain flight support experimentation hardware required by industrial researchers. This may include across-the-bay carriers as well as middeck augmentation racks or derivatives thereof. Both analytical and physical integration support are required for experiments conducted under JEA's. The NASA support for JEA's is directly proportional to the number of commercial R&D flight experiments scheduled and it is intended to encourage private sector use of space facilities. The use of ground-based research facilities, aircraft, and sounding rockets for commercial experimentation will be given emphasis in order to provide limited access to the microgravity environment for certain commercial experiments. Sounding rocket use will allow proof-of-concept testing and hardware check-out in a limited duration microgravity environment.

Centers for the Commercial Development of Space (CCDS):

While JEA partners receive no direct government funds for their work, another NASA commercial program -- Centers for the Commercial Development of Space -- provides consortia of industry and academia with seed funding for research leading to the development of new commercial uses of space. The CCDS's are nonprofit consortia consisting of universities, industry, and government (especially state and local government) working closely with NASA. The overall objective of these CCDS's is to stimulate and conduct high technology research based on the characteristics of space. The CCDS Program began in late 1985. The first two solicitations have resulted in the selection of nine CCDS's. These 9 CCDS's involve 58 private companies, 22 universities, and 6 other government agencies in their research efforts.

Recently, a technological breakthrough of potentially immense social and economic benefits was announced, namely, the discovery of a higher temperature

superconductor. Dr. C. W. Chu (University of Houston) and Dr. M. K. Wu (University of Alabama in Huntsville) reported on a copper oxide/rare Earth component whose transition temperature is above that of liquid nitrogen. NASA and NSF are very proud to be associated with this significant discovery through support provided by MSFC and our CCDS in Houston which Dr. Chu directs and our CCDS in Huntsville in which Dr. Wu is an active participant. The discovery of this and other materials with higher transition temperatures may have a positive impact on electrical and electronic subsystems in spacecraft. There is also potential for further microminiaturization of components resulting in more efficient systems requiring less power, less need for heat rejection. Another spacecraft application of superconductivity may be energy storage.

In order to maintain momentum in commercial use of space activities, NASA will continue to establish CCDS's in FY 1988. Institutions with strong research capabilities in science and engineering, in collaboration with industry and/or industrial associations, will be encouraged to participate. Awards are planned for FY 1987 and FY 1988 for an eventual total of up to 18 CCDS's operating simultaneously. NASA's individual CCDS funding is planned for 5 years in order to stimulate and stabilize the Centers' activities. NASA's support, on a year-to-year basis, will depend on a favorable annual review of the Centers' progress in stimulating commercial use of space. There is a mandatory requirement for industry participation in each CCDS, including the expenditure of corporate resources. NASA support will be reduced and finally discontinued at the end of 5 years as the successful CCDS's achieve self-sufficiency.

NASA's CCDS plan includes the following new elements: establishing cooperative agreements with CCDS's for the use of NASA facilities and capabilities in the conduct of the research programs, incorporating the CCDS's into the NASA outreach networks described above, and providing CCDS's with access to the NASA data bases.

Sounding Rockets:

A program OCP recently initiated for commercial payloads is use of sounding rockets. These small experiment-carrying rockets can supplement Shuttle low-gravity research time. Although sounding rockets can only supply a few minutes of weightlessness compared to that of many days upon the Shuttle, a few minutes time can be extremely valuable to some materials processing experiments. Currently, NASA Field Centers are evaluating the concept and we plan to choose one of the centers to operate the program.

Commercial Expendable Launch Vehicles:

A substantial amount of media attention has been focused on one specific commercial space activity -- space transportation, in particular, expendable launch vehicles (ELV). NASA endorses the development of U.S. private sector launching capabilities and has proceeded to transfer authority to the private sector to use NASA-controlled facilities and capabilities for commercial launchings. The General Dynamics Agreement to privatize the Atlas-Centaur was sent to Congress on September 8, 1986, pursuant to Section 110 of P.L. 98-52. The House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Transportation and the Senate Committee on Appropriations have all endorsed in the agreement. The House Committee on Appropriations, however, requested that NASA not implement the Agreement until the Surveys and Investigations Staff examined some issues. In mid-February, NASA received concurrence from the Committee on this Agreement. We are also currently negotiating with McDonnell-Douglas on the terms of privatizing the Delta vehicle.

Concerning non-NASA ELV's, an agreement with Space Services, Incorporated, was signed in 1986 allowing use of NASA facilities for the launch of the privately developed Conestoga vehicle. Martin Marietta has requested an agreement for use of NASA facilities for their commercial Titan program. They are currently reviewing a draft Agreement which NASA provided them in December 1986.

Technology Utilization:

The Technology Utilization Program accelerates transfer and use of NASA-generated technology to U.S. industry. The experimental agreement between the NASA IAC at the University of Southern California and the Far West Federal Laboratory Consortium (FLC) has been a successful endeavor over the past year. We are currently negotiating with the FLC to develop an agreement to share information between the NASA IAC's and over 300 federal laboratories. We expect that the use of NASA-developed technologies will significantly increase as a result of this interaction, eventually impacting overall U.S. industrial strength.

The privatization of NASA Tech Briefs journal continues to be a success. Tech Briefs is a privately published quarterly publication which contains descriptions of new NASA technologies. Circulation has increased by about 60 percent over the past 2 years. There are currently over 125,000 subscribers and the number is increasing by 5,000 to 8,000 per month.

Under the Acquisition, Dissemination, and Network Operations Program in FY 1988, NASA plans to strengthen the Technology Counselor network at its field installations to provide for expanded identification of NASA technical capabilities and expertise. This capability and expertise is necessary for matching and crosscorrelating NASA technology with industry needs specified by NASA IAC's. To facilitate timely and efficient interaction between Technology Counselors, IAC's and other organizations in the NASA technology transfer network, a coherent, microcomputer-based communications system is planned for FY 1988. Increased effective communication and data storage and retrieval systems will greatly enhance the overall capability of the network to coordinate technology transfer activities, and respond to user needs efficiently with minimum overlap and duplication of effort. Moreover, the system will enable technology transfer managers to maintain appropriate controls over the process to insure overall program effectiveness and management accountability.

In the Technology Applications Program, specific projects using NASA technology are developed. I am very pleased to report that we have the first human

trials of the Programmable Implantable Medication System (PIMS). This is a device developed from NASA technology which is implanted into the body and supplies metered doses of medication into the system. It has application for diabetes using insulin dosages and for cancer using morphine. Three diabetics were implanted with PIMS at Johns Hopkins University Hospital in the fall and initial reports are very positive.

Small Business Innovation Research (SBIR):

The SBIR Program is intended to increase participation of small, high technology firms in NASA programs. The program is structured in three phases. Phase I is conceptual definition of proposed projects. Phase II is development of proposals. Phase III is commercial application or government contracting (without SBIR funding).

NASA is very pleased that the SBIR Program was extended for 5 years. It has proven to be popular as well as effective. I want to take this opportunity to thank the Committee for its participation in the extension of this program.

International Commercial Space Development:

The United States remains a world leader in commercial space development but Europe, Japan, and Canada are all increasing space activities in general with an emphasis on applications. Foreign competition in the areas of space launch services and remote sensing is already intense, and there are large foreign programs which will compete with the U.S. lead in communications satellite technology.

Although materials processing in space (MPS) is a relatively new area of commercial opportunity, it is widely considered to have great promise. Outside of the U.S., Germany has the most active program in the field of microgravity sciences and applications, which includes MPS. Germany has clearly established long-range objectives in this field. These include a steady

program of Spacelab flights, such as D-2 in the third quarter of 1991; continued use of sounding rockets; and plans for utilization of the Space Station, platforms such as EURECA and the proposed Man-tended Free Flyer for microgravity experiments. These facilities will be used for both basic research and commercial applications. In preparation for these future activities, the German national aerospace research center (DFVLR) has just opened a Microgravity User Support Center in Cologne for testing and other ground-based activities in preparation for flight experiments. It is the intention of the Germans that this Center will be the key European center for such activities in the Space Station era.

Next in capabilities, but with considerably less flight time, is Japan. Japan has purchased approximately one-half of a Spacelab mission for experimentation but it will not fly until 1991. Nonetheless, Japanese industry is sufficiently interested in the potential for commercial applications to have established consortia among major Japanese firms to pursue microgravity experiments in space. Microelectronics is an area of particular interest. The Japanese are also planning a free-flying spacecraft for microgravity experimentation. Ground-based experimentation is underway as well as use of a method of dropping payloads from balloons to obtain limited microgravity period.

Summary:

The Office of Commercial Programs actively supports national and agency commitments to the commercial use of space. Although progress has been achieved, much remains to be done. The 2-year grounding of the Space Shuttle will, as a minimum, result in a corresponding delay in achieving some of the national commercial space objectives, but it also provides the opportunity to focus on the achievement of others. NASA support for commercial space activities has not diminished even though NASA will no longer routinely provide launching services to private sector satellites in competition with U.S. and foreign commercial launchers. Nevertheless, NASA intends to honor its obligations under the existing and planned cooperative arrangements since these efforts

are R&D and Shuttle-unique. Agencywide efforts to develop partnerships with the private sector to exploit the opportunities provided through the civil space program continue.

The Office of Commercial Programs looks forward to a very productive FY 1988 and the continued support of this Committee. I will be pleased to answer any questions the Committee may have.

Mr. NELSON. All right, you have nine centers now.

Mr. GILLAM. Yes, sir.

Mr. NELSON. Are you getting ready to select any more?

Mr. GILLAM. This year we would expect to select between three and five. We asked people to write us letters if they intend to propose. We have received notices from 54 different installations or institutions that say they plan to propose in this go-around. On average we've selected four to five a year.

We would expect to reach a steady state—we originally expected to reach a steady state of about 15 centers in operation. However, with the expanse of the areas that can be and should be covered in terms of commercial uses of space, ranging from communications satellites to microgravity processing, to remote sensing, to launch vehicles, to space power, to various others, we're considering whether or not we can stand within our runout budget to go to 20. But the current plan is to go to 15.

The current budget indicates that we will probably select three or four this year, and then next year we would select whatever number it takes, either two or three, to get us to the 15. But we are considering the idea of maybe going to 20.

Mr. NELSON. Are you involved at all in the JPL research that they're doing on the Excimer laser, and can you give us a report on that?

Mr. GILLAM. We're involved in the work, but not the JPL work on the Excimer laser. We have done some work on technology transfer associated with the Excimer laser. And some of the technology transfer work that I believe that we've done is associated with the breakdown of whatever the material is that forms in the arteries and veins to plug them.

Mr. NELSON. Plaque.

Mr. GILLAM. Yes, plaque. And we have been working in that regard. We have also been working with a program through Research Triangle in North Carolina to, I believe if I'm not mistaken, to use the Excimer laser in the process of shoe manufacturing. So we've had those two areas in terms of technology transfer.

But in terms of the laser itself, that's outside the scope of my ability to be able to give you a reasonable technical discussion on the laser.

Mr. NELSON. Let me tell you what the comment was over here. He says that's the heart and soul of the operation.

Mr. GILLAM. That's it.

Mr. NELSON. You or any of your assistants, can you——

Mr. GILLAM. Talk more about the Excimer laser work?

Mr. NELSON. Whether or not it is being perfected as a substitute for heart bypass surgery.

Mr. GILLAM. It's being worked on. I have someone here that can tell you more about what's——

Mr. NELSON. All right, would you?

Mr. GILLAM. Mr. Henry Clarks is our director of technology utilization.

Mr. NELSON. Just a short little answer. Come on up here.

Mr. CLARKS. Yes. A lot of the funds that we put into the Jet Propulsion Laboratory, they're used not only for technology transfer but for the reengineering or the redevelopment of the technology

that we are experiencing. And the Excimer laser technology, as you do know, that technology is being considered for some of the star wars activity. And there has been some connection between the activity that we have done so far and the application of that technology against applications for star wars. So it is going through redevelopment.

Mr. NELSON. I want to know, what about the technology on heart—on clogged arteries. What's the latest on that?

Mr. CLARKS. I don't have an exact answer.

Mr. NELSON. Give it to us, if you will.

Mr. GILLAM. The best answer that I have right now is it's an experimental program and they're using it to destroy plaque in the leg and veins in the leg before they try it on the more hazardous parts of the body.

Mr. NELSON. Do they have this laser such that when they break open the plaque that it does not damage the artery wall?

Mr. GILLAM. That's part of the way they're trying to work the system out and to develop the use of its capabilities.

Mr. PACKARD. Would the gentleman yield for just a moment?

Mr. NELSON. Certainly.

Mr. PACKARD. Normally when plaque breaks loose and flows in the normal vein or artery it gets back to the lungs, the heart, the brain. And the biggest threat, of course, is either a heart attack, a thrombosis or a stroke. Would you respond to that concern?

Mr. GILLAM. I'm not an expert in that area. But my understanding is that use of the Excimer laser pulverizes the plaque to a point that it vaporizes it, and those effects are not present.

Mr. NELSON. Okay, we'd like some specifics on that.

Mr. GILLAM. We'll get that for the record for you, sir.

[The material referred to follows:]

PULSED EXCIMER LASER

Preclinical animal data on pulsed excimer laser angioplasty was performed using a JPL magnetically switched excimer laser installed at Cedars-Sinai Medical Center. Our results of tissue ablation studies and animal studies were presented at the 35th Annual Scientific Session of the American College of Cardiology in March in Atlanta, Georgia. Work is still progressing on construction of the Cedars excimer laser.

Also, attached is an article from the December 2, 1986, issue of the Los Angeles Herald Examiner dealing with the benefits of this laser.

Mr. NELSON. All right. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. Can you give me some idea what you have been doing within the office, working with people like investment bankers that will assure that in the years just ahead that we will be able to attract risk capital into the space-based economy?

Mr. GILLAM. We have, as a part of our outreach program, Congressman, been working with several groups in the New York area, in the securities and exchange area, and in areas associated with investment banking to make them aware of what we're doing. But we have not had a major program to get them—the program has been an educational program so far because we don't have a lot of things that are ready for the commercialization stage if you wish.

But we have had several programs conducted in New York to bring them up to speed on what we're all about and what we're

doing. We've had programs on the West Coast with the financial community from the San Francisco area. And it's really a program to inform others at this stage of the game, of what we're doing, what the potential is and what the risk might be as we perceive them in the future.

Mr. WALKER. Are we doing anything about matching up small innovative technology firms that you may come across with those investment bankers, so that the investment bankers begin to understand what the innovative technologies are that will be space based that might be something they'd want to risk capital on, if not the near future, at least the distant future?

Mr. GILLAM. In our technology transfer program we are matching the small new product companies that I mentioned with some investment community people so that they can do that. We have not reached that stage in our space-based activities as yet.

Mr. WALKER. Let me ask you about the whole business that you discuss in your testimony about the commercialization of ELV. You make mention of the fact that the General Dynamics program with Atlas Centaur is going forward and that you are working with McDonnell Douglas on the commercialization of Delta at this point.

Where are we moving in terms of NASA making an absolute commitment to purchase launch services from these kind of domestic vendors, rather than purchasing vehicles?

Mr. GILLAM. There's a meeting—the movement—and I'll try to give you an up to date answer to the question. Purchasing—I think NASA has made the decision that it will purchase launch services as opposed to launch vehicles. Now what that definition of launch services involves in terms of NASA quality assurance oversight or reliability oversight, has not been defined yet. There is a meeting scheduled tomorrow within NASA to begin a definition of what we mean by buying launch services.

Mr. WALKER. When do you expect to have that definition?

Mr. GILLAM. I would expect it within 2 to 3 weeks, sir.

Mr. WALKER. When that definition is ready, would you see to it that it is communicated to this committee?

Mr. GILLAM. Definitely.

Mr. WALKER. And also direct it to me as well. I'm very interested in seeing how we end up with that definition.

If I wanted to book an Atlas launch, how would you help me?

Mr. GILLAM. A couple of ways. One, I would put you in touch with the appropriate GD representative who could tell you what GD had available in the way of Atlas H, I, J, K, L, M or whatever configurations that they had available. And we would work with GD as rapidly as we could to get an estimate of the cost that NASA would be charging for the use of NASA tools, facilities, equipment and services that might be supplied in support of that so that GD in turn could get its other estimates together and provide the customer with a quote for that.

And we would also advise the customer that there were certain other hoops that he would have to go through. We would advise you if you were the customer, that there are certain other hoops with respect to licensing of the spacecraft, and of the launch with the Department of Transportation and with the appropriate other. If this was a communications launch that you were talking of, we'd

provide advice on how to approach the FCC and what was required in terms of approaching the FCC.

Mr. WALKER. Are those interfaces with the Department of Transportation working at the present time?

Mr. GILLAM. To the best of my knowledge they are, sir.

Mr. WALKER. They are from your perspective. If I were someone who had what would be regarded as a fairly grandiose idea at this point. Let's say I was an entrepreneur that decided that what I wanted to do was build a space-based hotel. What would you do to help me at the present time?

Mr. GILLAM. That is a tough question. I would work with you on the definition of your project, and we would have the NASA people with the appropriate kinds of experience in environmental control-life support systems and all of those kinds of things work with you. The people who have done some advanced studies and advanced planning on Space Station would also work with you on developing a solid proposal that was technically feasible. And beyond that, I believe what we would do would be to work out some sort of arrangement or agreement wherein NASA support that you required could be provided to the project on a reimbursable basis, and since this is a space-based hotel, it's something we haven't run across. But I think our support would be limited to that. But the role of the Office of Commercial programs, as we perceive it in the Federal Government in cases like that, are roles of facilitating the actions on the part of the Government that are necessary to enable you to accomplish your objective, and I believe we would do whatever we jointly determined or found out to be necessary.

Mr. WALKER. You are confident that somebody walking through your door with that kind of a proposal, even though it seems a little far-fetched, is not being turned away with the idea that that it is too farfetched for us to take up?

Mr. GILLAM. They are not turned away by our organization, I hope.

Mr. WALKER. One final question. Where are we with regard to the concept of perhaps selling an Orbiter to private enterprise as a way of paying for the Orbiter that the government is about to buy? That is a proposal that's been around, but my impression is that NASA has been dragging its feet on that. Where are we?

Mr. GILLAM. Your impression is correct, Congressman. We, as you know, last year, January 1986, issued a CBD notice asking for expressions of interest. We then proceeded to write an RFP, a request for proposals. We had plans to submit that RFP to the public for comment prior to publishing it as a request for proposals, but we never got beyond that stage.

Mr. WALKER. Why?

Mr. GILLAM. When the decision was reached that NASA could no longer fly commercial payloads in August of last year, 1986, August 15, I believe was the date of the pronouncement, the Administrator put together a team headed by the Deputy Administrator to review questions, and as a member of that team, we have been looking at various scenarios through which such an arrangement might be accomplished, and because of the requirements, for example, of the Deficit Reduction Act of 1984, it would look like the Government would probably wind up being a major user of that capability, and

therefore the terms of the Deficit Reduction Act and the terms of OMB circulars associated with how you would price out and compare—it's a make-or-buy decision kind of guidance that we got on that, and we have not been able to work a credible scenario for the private sector to finance an Orbiter and lease it to the government and not have it cost the Government more money than it would cost if the government built it itself.

Mr. WALKER. Over what period of time, though? Over the 20-year life of the Orbiter or—you know, we're talking about putting up $2.5 billion right up front, right now. That's money we can't afford.

Mr. GILLAM. But we have been looking at a 10-year scenario, and at the 10-year scenario we can't make it work that it's more economical to lease it than to buy it.

Mr. WALKER. But one thing that discourages me on this is that something is then being worked internally. Why wouldn't you go out with a proposal to see whether or not somebody in private enterprise might have an idea as to how that could be done in a creative way? Aren't there some people outside who know a little bit about financing, too, who might have some creative ideas as to how that might be accomplished?

Mr. GILLAM. Yes, sir, there probably are. But in order to accomplish it, there still has to be cost comparisons made between the cost of leasing and the cost of buying. And we have not been able to find any credible scenario that would lead you to believe that the cost of leasing is less expensive than the cost of buying it.

Mr. WALKER. Well, I understand what you're saying to me, except that the bottom line is that that has always been NASA's position. NASA has always taken the position that if we could get Congress to buy this for us, we obviously don't want to get it out of our hands. And so therefore they have internalized the whole thing, and we have managed not to bring people in who may have created financing kinds of ideas for purchase of an Orbiter and, you know, every time it seems that we come up against that wall whenever somebody suggests that there might be some way of getting the payment for some of these big projects off the back of the taxpayers. And—well——

Mr. GILLAM. We still have a prepared RFP, Congressman.

Mr. WALKER. Excuse me?

Mr. GILLAM. We still have a prepared, completely prepared and staffed RFP.

Mr. WALKER. From my perspective, I'd like to see that go forward, and maybe what we're going to have to do is force it to go forward through the authorization process.

I thank you.

Thank you, Mr. Chairman.

Mr. NELSON. Mr. Volkmer.

Mr. VOLKMER. The only thing I'd like to know about, what ever happened to privatization for the new Orbiter?

Mr. GILLAM. That's a question that Congressman Walker just asked. The committee that was appointed by the Administrator last September 1, or thereabouts, is still looking at the question of can we devise a credible scenario under which such an activity might take place.

Mr. VOLKMER. You said you're ready to go forward with an RFP?

Mr. GILLAM. We had an RFP that was already completed last July, asking for proposals for a private Orbiter.

Mr. VOLKMER. What happened to that?

Mr. GILLAM. It's on hold, pending our look at can we develop a scenario, conceivable scenario, under which it would be cheaper for the Government to have the private sector finance the Orbiter and lease it back versus having the Government buy the Orbiter.

Mr. VOLKMER. Well, who put it on hold?

Mr. GILLAM. I presume it was the Administrator and the team that were looking at it, so that we could look at the changed circumstances that happened when the President made the decision on payloads, on commercial payloads on the Shuttle. We believed that we had a credible scenario when commercial payloads could fly on the Shuttle. But with the commercial payloads not being allowed to fly on the Shuttle, it impacted that process substantially.

Mr. VOLKMER. As far as payments from the private sector, but not for need for a shuttle.

Mr. NELSON. Would the gentleman yield?

Mr. VOLKMER. There's still going to be a need for a shuttle.

Mr. GILLAM. We would still be——

Mr. NELSON. Would the gentleman yield? Hold on just 1 second.

Mr. VOLKMER. Yes, I yield.

Mr. NELSON. Mr. Gillam gets beat upon the shoulders and the head every now and then, but this is one that where the President announced his policy, they were going to take the commercial payloads off the Shuttle, and therefore the commercial viability of being able to sell Orbiter cargo bays was not as attractive from a commercial standpoint.

Mr. VOLKMER. That's when we still had four Shuttles.

Mr. GILLAM. No, we only had three when the decision was made in August of——

Mr. NELSON. That was the decision that was made last year. We were struggling, trying to get that replacement Orbiter.

Mr. VOLKMER. Maybe I'm hard-headed and I can't get it through my thick skull, but I'll start with this premise. Do we still need a fourth Orbiter?

Mr. GILLAM. I would have to say from all of the studies that I have seen, we need a fourth Orbiter and likely may need a fifth. Our proposal was written for an additional Orbiter, so that whatever the Government owned, this would be for an additional private Orbiter. It wasn't written for a number, for either the fourth or the fifth.

Mr. VOLKMER. Well, I cannot really see if the Government decides there won't be any more commercial payloads on the shuttle, where that impacts on the need for a fourth Orbiter. Because in my opinion we need a fourth Orbiter without the commercial payload.

Mr. GILLAM. Yes, sir. But that impacts on whether or not you can get a viable commercial Orbiter in operation.

Mr. WALKER. Would the gentleman yield?

Mr. VOLKMER. Yes. I don't understand his logic. Go ahead.

Mr. WALKER. That's the thing, there is no logic to that. First of all, a leaseback arrangement could be arranged that carries Government payloads.

Second, the commercial viability of it is based upon mature technology. There are going to be commercial services that will have to be flown aboard the Shuttle that are shuttle-unique. That could be a very profitable market for someone in the near future. The Faget modules, for instance, that will be a commercial venture, could be a very profitable kind of thing for somebody to be flying, and so we have not eliminated commercial ventures from the Shuttle. We have simply said that mature technologies are going to fly aboard ELV. I mean to premise a decision on something which is not reality is totally incomprehensible to me.

Mr. VOLKMER. I can't blame Mr. Gillam for that, but I do think, Mr. Chairman, that perhaps we should take this up with the Administrator, and I think Mr. Gillam should be freed from the chains that bind him, be permitted to go ahead and still explore it.

I yield back the balance of my time.

Mr. NELSON. One of your colleagues, Bob Aller, another Associate Administrator, he had the temerity to ask to go first one day, and it was when this committee was loaded for bear, asking questions that only the Administrator could have answered.

Mr. GILLAM. I heard about that.

Mr. NELSON. They asked them all of Mr. Aller.

Mr. GILLAM. I understand. That was why I was so nervous. [Laughter.]

Mr. NELSON. Okay. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

The purpose, or one of the purposes, of course, for commercializing the launch capabilities is that there would be some money saved through commercial ventures and through private enterprise.

If we imposed the same kind of inspections and restrictions and regulations on the private process, will there be any savings?

Mr. GILLAM. My immediate response to you is that there would probably not be.

Mr. PACKARD. It would appear to me that that's a concern of industry, is that they will not find—it will become too expensive, just like it's too expensive for the Government, if they have the same oversight, the same inspection requirements, and tracking, and basically regulations.

Mr. GILLAM. If nothing changes, Congressman, I would expect that nothing will change.

Mr. PACKARD. That's right. And therefore industry would tend to back away from using—it would push them toward Ariane or some other less cumbersome process, it would appear to me. I'll be very short, and we'll be done in time for the vote, Mr. Chairman.

Who has the lead in finalizing commercial ELV agreements?

Mr. GILLAM. Within NASA? It's our office that does that, sir.

Mr. PACKARD. And what office is that?

Mr. GILLAM. The Office of Commercial Programs.

Mr. PACKARD. And who has the final approval authority?

Mr. GILLAM. Well, that's a complicated process. In the one commercialization agreement that we have signed, we sent a negotiated coordination draft around to all of the agencies that were members of the Commercial Space Working Group. We then sent it through the coordination circuit within NASA. We then sent it to

all four of the congressional committees, the two authorization committees in the House and Senate, and the two appropriations committees in House and Senate, and when we received approval from all of those, the Administrator finally approved the negotiated agreement.

Mr. PACKARD. And how do you coordinate these agreements with Admiral Truly?

Mr. GILLAM. They are coordinated during the internal NASA process. As a matter of fact, Admiral Truly has a representative on the team that negotiated the agreements.

Mr. PACKARD. Who makes the decisions on NASA's use of commercial launch services?

Mr. GILLAM. On NASA's use of commercial launch services? It is Admiral Truly.

Mr. PACKARD. Admiral Truly himself.

And when will NASA be issuing the secondary payload manifest for the shuttle?

Mr. GILLAM. That's a tough question. As you're probably aware, we declared a moratorium on signing JEA's last October, until we could tell our joint agreement partners when they might expect a launch. In the interim we have had a report from General Phillips on reorganization; we have had a review by a task force within NASA to determine what should be our allocation method for allocating space to various types of secondary payloads, science payloads, commercial payloads, military payloads and others.

We have worked out a percentage arrangement that we believe is equitable. The Administrator has not concurred in that arrangement yet. The recommendation has been made to him. He has not approved that recommendation. And we would expect the secondary payload manifest within 6 weeks of his decision, sir.

Mr. PACKARD. Is your office involved in the decision regarding the use of ELV's for some of these experiments?

Mr. GILLAM. We are involved in the use of ELV's only in the sense that we might be a potential user. In other words, we might have an arrangement with the private sector that is going to use ELV as a secondary payload or as a piggyback for another NASA payload. But other than that, the only involvement that NASA has with ELV's is to purchase or to procure the services for its own missions, and so our office as a commercial office is not directly involved in that. We have an advocacy role for advocating that they do it in some commercial manner.

Mr. PACKARD. What steps are you taking then to make the Administration policy of commercializing launches a success?

Mr. GILLAM. We have taken several. We have gotten the first range use agreement negotiated with SSI. We have gotten the first authorization to privatize with General Dynamics. We are currently in negotiations with McDonnell Douglas to commercialize Delta. We are currently in negotiations with Martin Marietta to provide support capabilities to the Titan launch. That's an Air Force vehicle, so the basic agreement would be the Air Force, but we are working an agreement with Martin Marietta to provide supporting services such as payload processing support to their commercial customers. We have worked with the Hughes/Boeing combine on the conceptual development of the Jarvis commercially developed

heavy lift launch vehicle. We have taken many steps in those regards to assist in the commercial development of ELV's.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. NELSON. We are going to recess here, go on over and vote. This is the vote on the rule on the Contra aid. All right, now, this is not the vote on the previous question. This is just the vote on the adoption of the rule, and it is my understanding then there is three hours of debate once the rule is adopted. But, anyway, as soon as we are through voting, whatever, at this time, we will come right back and resume the hearing.

[Recess.]

Mr. NELSON. All right. Mr. Konnyu, it is your turn.

Mr. KONNYU. Thank you, Mr. Chairman. Mr. Gillam, please characterize your outreach program during the current hiatus of Shuttle launches.

Mr. GILLAM. During the hiatus, as a result of the accident and the downtime associated with the *Challenger*, we undertook an effort to refocus our outreach activities, not to change the outreach activities but to change the focus or the direction in which we were taking those activities.

We had focused our outreach on research and experimentation in space and encouraging companies to do Joint Endeavor Agreements, and those types of things. During the downtime and while we fly off the backlog of payloads that are accumulating during that downtime, we have focused our outreach activities on technology utilization and technology transfer in support of the international competitiveness activities of the Administration. We have put less emphasis on flight activity because there will be such protracted delays in achieving flights. So we have modified from focusing on doing research in space to doing whatever activities you may wish to do to use technology that we have already developed and we already have on the shelf.

Mr. KONNYU. Coming from a high tech district, can you explain the relative budgetary emphasis in technolcgy?

Mr. GILLAM. The relative budgetary emphasis in technology? The budget emphasis on technology is generally focused in the NASA Office of Aeronautics and Space Technology. They have a program that focuses on aeronautics and they have a prcgram that focuses on the disciplines in space technology. Space technology including things like space power, space structures, and those types of disciplines.

My assumption is that approximately 10 to 15 percent of the entire NASA budget is spent in that area on technology development, and our office works on the aspect of once the technology is developed, we form the bridge between the development of that technology and the utilization of that technology in the private sector. So we handle the spinoff of NASA technology to the private sector.

Mr. KONNYU. In hearings Dr. Fletcher, as well as others, through this committee I get a real sense of uneasiness over our standing internationally in terms of commercial space activity for obvious reasons. So let me address that uneasiness by asking the following question.

Do we have an edge with respect to commercial space activity in these following five different areas, and I will ask them one at a time. First of all, do we have an edge in materials processing?

Mr. GILLAM. Internationally, Congressman, I would have to say that my guess would have to be that the Soviet Union has an edge in materials processing and that they are leading. I think that we are probably at about the same level or maybe slightly ahead of countries other than the Federal Republic of Germany, which has done an extensive amount of materials processing work using the Spacelab and Shuttle vehicles.

Mr. KONNYU. Okay. But I don't quite understand if you use—you know, you just said the Soviet Union, but I don't know that they're involved in commercial space activity.

Mr. GILLAM. Well, materials processing right now is at a research stage; there is very little in the way of commercial materials processing activity that has reached the stage where it is commercial. I can only think of one item, which are the small monodispersed latex spheres that were produced for the National Bureau of Standards and they in turn sold them on the commercial market. So materials processing in space is very much at a research stage right now, and I would have to say that the Russians have done more research in that than we have had the opportunity to do.

Mr. KONNYU. And one of the things used in Silicon Valley a lot is gallium arsenide. What about that material?

Mr. GILLAM. There are several experiments that are waiting to look at various processes of producing gallium arsenide. As a matter of fact, we have three Joint Endeavor Agreements, these are cooperative agreements with the private sector where the private sector provides the experimental device, we provide the flight and we share the data. It's a cooperative partnership arrangement.

We have three different processes looking at the production of gallium arsenide that have been proposed to us and they are waiting on flight opportunities.

Mr. KONNYU. But you don't know when they're going to fly, right?

Mr. GILLAM. My guess is that they will fly sometime in the late 1988, early 1989 timeframe.

Mr. KONNYU. Okay. Switching from materials processing to communications technology, does the United States have an edge in communications technology?

Mr. GILLAM. I think we have the lead currently. I don't know if we will retain it. The others are coming fast.

Mr. KONNYU. How about in remote sensing devices?

Mr. GILLAM. We had an edge in that area through the Landsat Program that is currently in orbit. I think we are probably in danger of losing that lead.

Mr. KONNYU. To——

Mr. GILLAM. To the Europeans with the Spot Image system and even the Japanese are working, doing extensive work in civil remote sensing.

Mr. KONNYU. How about an edge with respect to launch vehicles? Who has it?

Mr. GILLAM. In terms of launch vehicle technology, I believe we have the edge. In terms of commercial launch vehicles, I believe

the Europeans have the current edge because they have developed the first commercial system that is on the market and it is there and operating. The U.S. commercial systems are just in their infancy, so on that basis technologically we are as capable as they are, but we have not had either the experience or the development in a commercial sense that they have had in terms of launch systems. But I believe that our technology, we have a technological lead in launch systems, but they have the commercial edge in commercializing it.

Mr. KONNYU. If you could take off your official hat for a minute and just be an interested and knowledgeable U.S. citizen and if you look back at the world in terms of commercial space activity, why is it that the Europeans, a set of countries known as less commercial or less free enterprise than the United States, would have such a lead?

Mr. GILLAM. In terms of commercial systems, in terms of things like Spot Image and the Ariane launch system—it's kind of hard for me to answer that question.

Mr. KONNYU. See, to me it seems if it relates to free enterprise type commerce, we obviously, from a United States perspective, should be leading and not the Europeans. So what happened there?

Mr. GILLAM. It's a subject that I haven't thought about and I'm afraid I can't give you an off-the-cuff answer. I would like to think about that and supply it to you for the record.

Mr. KONNYU. Okay.

[The material referred to follows:]

The European Space Agency [ESA] turned the Ariane launch vehicle system over to Arianespace, a company one-third of whose shares are owned by the French national space agency, in 1983 after system development was completed. ESA and its members rely on Arianespace for all launch services, including those of government payloads. At that time, the U.S. was still offering only reimbursable launch services using the Shuttle and NASA expendable launch vehicles; there were no U.S. companies in the market.

U.S. policy has since changed and NASA and other government agencies are supporting the entry of private companies into the commercial launch business. Five companies are actively marketing launch services, and some have already signed agreements with U.S. and foreign customers. While the Europeans have a head start in the commercial launch services market, the U.S. companies, with their excellent technology and capable marketing, can be expected to compete effectively.

Mr. KONNYU. Do you see a real commercial component of Space Station as it is now being planned in NASA?

Mr. GILLAM. When you say commercial component, do you mean an element of the station itself that is commercially supplied?

Mr. KONNYU. Sure. A reserved portion.

Mr. GILLAM. Yes. I see the possibilities for it.

Mr. KONNYU. Do you want to spell it out a little bit?

Mr. GILLAM. Well, I see the possibilities for commercial platforms that will fly along with Space Station which will, while not necessarily be an attached component, will be a component of Space Station. I see the potential of the Max Faget module being attached to and becoming an integral part of the Space Station as a commercial concept. I have heard people considering proposals for commercially supplying things like space power to the Space Station and augmenting the base power level that is being developed for the

Space Station. So I see the possibilities for several commercial ventures associated with the Space Station.

Mr. KONNYU. Okay. I am an accountant so I like to talk about realities, so let me ask you on that point a specific question. Are you personally pushing for purchasing those things for the Space Station?

Mr. GILLAM. We are advocates of commercial ventures wherever they may come about ranging from terrestrial activities such as payload processing in support of commercial launches up to and through commercial space ventures which are exclusively commercial. So yes, we are pushing. Some of the concerns of some of our commercial potential users——

Mr. KONNYU. You use the word "we"—Royal we or——

Mr. GILLAM. The Office of Commercial Programs.

Mr. KONNYU. How about you personally?

Mr. GILLAM. Very much so. We made strenuous inputs into the Space Station with respect to the microgravity levels that might be expected in the habitable modules and in the experiment modules on Space Station, and we like to believe that we influenced the modification of the design from the single keel to the dual keel station to accommodate those potential commercial requirements. That may be a little egotistical but we were one of the people making noise about that.

So yes, we are the recognized advocates within the agency because we make noise in favor of commercial activities.

Mr. KONNYU. Okay. Finally with respect to commercial R&D onboard the Space Station, do you see an opportunity for it?

Mr. GILLAM. Definitely. Our office's posture is that the commercial use of Space Station is one of the more strenuous rationales for the development of the Space Station. The Space Station itself changes drastically the economics of the situation from the capability that we have today. Today, you can go up in orbit on the Shuttle and you can produce for 4 or 5 days and then you bring your material back down and that is all the production time that you get. For example, Space Station offers the opportunity for continuous production, which changes the economics of the situation drastically and greatly expands the number of materials and products that you might be able to deal with in an economic sense.

Mr. KONNYU. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Smith?

Mr. SMITH. Thank you, Mr. Chairman. I just wanted to pick up on a comment that you just responded to, Mr. Gillam, that was interesting. In reference to I believe you said the Japanese and certainly Europeans, that they have the commercial edge and we have the launch system edge in terms of getting into space. That is kind of a sad commentary, isn't it? Is it the result of no policy, failed policy? What do we have to do to change it?

Mr. GILLAM. It has already been changed in a policy sense. The work that DOT, DOC, and NASA are doing to try to bring on line commercial ELV's within the country is an effort that should catch up with where they are in a very, very short period of time.

We had the capability of doing it, we just didn't have the policy initiative to do it.

Mr. SMITH. I can understand, I know you have it at the policy stage in terms of your statement here, but an entrepreneur comes to you and he or she is willing to do everything possible to get involved. It's an unlimited industry out there almost; there's no precedent for anything like this really, space exploration, getting involved in space.

Are you giving them everything that they need in terms of cooperation and information? I realize you can't give them money, but——.

Mr. GILLAM. We are trying very hard to give them everything that we can. For example, as far back as 1983—maybe NASA doesn't beat its drum enough—but in 1983, Space Services, Incorporated came to consult with NASA for doing the first private launch. There was a launch made from Matagorda Island in Texas by this small company.

NASA provided a tremendous amount of technical assistance and even provided hardware assistance to accomplish that first private launch. We provided technical assistance to the agencies that they had to deal with, and technical advice to the agencies that they had to deal with to get the necessary licenses to accomplish that launch. So we have been very involved in providing support to these kinds of endeavors and it probably isn't as widely known as it should be.

Mr. SMITH. Well, what do you see essentially as the impediments, as you see them now; specifically, let's just take the commercial involvement in Space Station and say ELV's, those two areas.

Mr. GILLAM. Based on the discussions that we are currently having with McDonnell-Douglas, I would have to say the major impediments are insurance and liability, risk sharing. All three of those are in the same arena. They are related to each other and that's the major problem that we are having right now in discussions as to what portion of the risk does the Government take, what portion is the commercial entity responsible for and who has what risk and who must cover what with insurance.

Mr. SMITH. That was going to be my next question and maybe you might go into that a little bit more. Just how specific are those discussions in terms of insurance liabilities, risk? Do you really get right down to the nitty-gritty, are they looking for 100-percent risk free—whatever you can divulge here.

Mr. GILLAM. Well, there are occasions where we think they are looking for 100-percent risk free. They do get down to the nitty-gritty. Where we are in our latest thinking is that for a launch that is being conducted commercially, if we lend them some Government equipment and they have control of it, then they are responsible for returning that equipment to the Government in an operable condition, which means that they bear the risk for what they have under their control. If we are controlling an operation in support of a commercial launch and something breaks down, we bear the risk of repairing that and fixing it because we are in control of it. And it is getting down to pieces of equipment. So it is very detailed and it's very comprehensive.

Mr. SMITH. It just seems like with—I think certainly this committee has expressed support for commercialization of space and certainly the Administration has, and I think the American people

support it. And perhaps more than any other industry in recent times, it seems like the stage should be set to do it, and yet it is not happening. I realize the *Challenger* accident set us back.

You mentioned that the Europeans are ahead in this regard in the commercial end. What are they doing differently? Maybe it's too obvious a question, but are they just more aggressive? What is the problem? Why are they ahead in that respect in terms of getting more people interested.

Mr. GILLAM. Well, when the Europeans conceived of the Ariane system and the Spot remote sensing system, they conceived of them as being government developed and transferred to the private sector for operation. So that was the program intent from pretty much the beginning. So they had taken an idea that I believe came from the United States in terms of the Communications Satellite Act of 1963, and they carried that concept into other areas other than communications satellites; they carried it into the launch process. The program planning from early on was that the Government entities would develop these systems and they would be turned over to a quasi-private agency because the distinctions between private sector and government in Europe are not as clearcut as they are here in the United States.

Mr. SMITH. Just one final point, Mr. Chairman. Most of the stuff that I've seen, or testimony that I have seen, regarding the ACTS Program, it has helped to maintain U.S. leadership in space based communications. Both the Japanese and the Europeans are developing the technology. Yet really NASA has proposed or is continuing to propose a cancellation of that. Is that consistent with what you want to do?

Mr. GILLAM. I would have to say that ACTS is a manifestation of a philosophical debate over what is the appropriate role of the Federal Government, that is continuously raged. It is clear to most people that the development of knowledge and the development of new technology, especially long term cutting edge technology, is the proper role for the Federal Government.

There is a great deal of debate as to what should be the Government's role in demonstrating that technology once it is developed. There is a version of an argument that says once that technology is developed, the private sector should take over the demonstration and development phase of the technology. There is another argument that says the Government should demonstrate the technology prior to the private sector taking over and proceeding with the development of that technology. That debate has been raging for at least 7 or 8 years, as far as I know, both within NASA, OMB and other elements that have to make such decisions as the ACTS and other decisions.

Mr. SMITH. I think that—correct me if I am wrong, but I thought you had said that the Europeans did just that and now they lead in ELV's, commercialization of ELV's. I mean, I don't want to—I'm certainly the last one to say the Government ought to be the promoter of—but we don't want to abandon American business either. I think they need help but by the same token, they need some leadership here, too. They need to know where we are going. I'm not sure anybody knows where we are going with the space program.

It seems to me that—I mean the *Challenger* accident set us back but it didn't change my mind about the fact that we ought to be in space as soon as we straighten out the problem and I believe that we have straightened it out.

I don't see where anything is different. Most of the witnesses that have come forth in the last few days regarding budgetary testimony have constantly referred back to the *Challenger* accident. The *Challenger* accident sure, it set us back but really should it change our commitment to the space program. I don't think it should. I don't think we ought to use that as an excuse. I'm not saying you are but I'm just making a point here.

Mr. GILLAM. Well, I don't really believe the Administration's posture on the ACTS program has been 100 percent consistent. The Administration perpetually proposes budgets without ACTS and Congress perpetually passes budgets with ACTS.

Mr. SMITH. As a final point, as a former businessman, maybe there aren't enough businessmen and women in Congress but you know, as a former businessman, most business people before they make a commitment, they have to know what they are committing to and I don't think they know. I think the American technology, the American business is the greatest in the world as far as I'm concerned, better than the Europeans, better than the Japanese, I don't care whose toes I step on when I say that. I think they are the best, but they need certain things. They are not looking for guarantees. That's not the American way. They just want to know, you know, what to expect, whether they are going to have 10 years to do something, 20 years to do something, 5 years to succeed or fail, whatever. They are not afraid of success or failure, or they are not afraid of failure, rather.

I believe and they believe that they can succeed but they need to know what the commitment is in terms of the whole space program and I think they are getting mixed signals on it. I think they are rearing to go in a literally unlimited industry. I think part of your responsibility hopefully will be to provide as much help as you can with some type of long term policy commitment.

Mr. GILLAM. I agree, Congressman Smith, and I happen to believe that this philosophical issue that I was talking about, we shouldn't have an absolute policy that says the Government will not do technology validation or technology demonstration any more than we should have a policy that says the Government will do it in every case. I think we ought to have a flexible policy that allows the Government to do what's best under the circumstances and in those instances where industry fails to pick up the ball or chooses not to pick up the ball or whatever, if it is important to the country, you ought to ensure that one of the two of us picks up the ball somehow.

Mr. SMITH. We have to decide to put the ball in the court somewhere. Thank you, Mr. Gillam. Thank you, Mr. Chairman.

Mr. NELSON. You said that five JEA's were signed within the last year and those were the ones that were already in progress. Have you initiated any additional JEA's in the last year? Discussions?

Mr. GILLAM. No, we have not, Congressman Nelson, and that seems to be one of the things that has impacted the program as a

result of the accident. We have not initiated any discussions for new JEA's since the accident—principally because of the delay.

It's obvious to everyone that there is a 2-year delay in flight opportunities but the delay in flight opportunities is much more than 2 years because we are creating a backlog and once we start flying, it will be a while before we can cut into that backlog significantly enough to have flight opportunities for additional experimentation.

The number of the people that we talked to about opportunities in space ask, when might I be able to fly and we respond, to be pragmatic about it, it would be sometime in 1990 or 1991. They say, come back and see us in a couple of years.

Mr. NELSON. All right. What you are telling me is all pursuant to Dr. Fletcher's moratorium?

Mr. GILLAM. No, no, not pursuant to the moratorium, it's the——

Mr. NELSON. Were the reasons for the moratorium different than what you just stated?

Mr. GILLAM. The basic reason for Dr. Fletcher's moratorium was when he signs a JEA with a guy, he would like for that guy to have some idea of when it is that he can expect to fly.

Mr. NELSON. So the reason is the same, for the moratorium?

Mr. GILLAM. Yes; it's related.

Mr. NELSON. All right.

Mr. GILLAM. I might add, we have about four Joint Endeavor Agreements in process, that as soon as we get the secondary payload manifest and get that worked out, we will probably be able to enter into those and those are the last four that are underway. We have no new ones in process.

Mr. NELSON. He will lift his moratorium for those four?

Mr. GILLAM. He will lift his moratorium when we have the secondary payload manifest and we will be able to tell those four, you will be able to fly in such and such a timeframe and then the moratorium will be lifted.

Mr. NELSON. NOAA is going to launch three GOE satellites by issuing a launch services procurement. What role will NASA have in launching the GOES satellites?

Mr. GILLAM. NASA is working on making a determination on that, Congressman. I wasn't directly involved but—I believe the letter from NOAA came in a little over a week ago, stating that that was their intent and NASA is in the process of making decisions on what role it will play in support of NOAA.

Mr. NELSON. So you don't know the answer to that?

Mr. GILLAM. I don't believe there is an answer inside NASA as yet. They are still working it.

Mr. NELSON. When do you expect an answer on that?

Mr. GILLAM. I don't know what the working schedule on that is and I'm not involved in that decision process so I couldn't really answer that one either.

Mr. NELSON. Okay.

Mr. GILLAM. Mostly support that would come from that activity would come from Admiral Truly's area, technical support to NOAA.

Mr. NELSON. Okay. We will ask him on that.

All right, Mr. Gillam—Mr. Perkins, I will get you up to speed whenever you want to question Mr. Gillam. Let me proceed here.

Mr. Gillam, if you will just move over and let me have Mr. Stadd come up. If you will take that center chair, and we will proceed. Your written comments are entered as a part of the record, so if you will summarize verbally and we will proceed with the questions.

**STATEMENT OF COURTNEY A. STADD, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION**

Mr. STADD. Thank you, Mr. Chairman.

Mr. Chairman, let me begin by thanking you and the other members of the committee for giving me an opportunity to make my maiden appearance before this committee to report on the status of the commercial space transportation initiative.

To date, domestic ELV manufacturers have signed over a dozen launch reservation agreements with satellite customers, and I'm pleased to announce that Martin Marietta has submitted mission review requests for two payload customers and we expect to receive a third request from another launch firm momentarily.

I have been informed that a young entrepreneurial firm by the name of American Rocket Co. has just initiated a licensing request for a test launch to be conducted later this year.

So I think the response of America's private sector to date is sending a clear signal to our foreign competitors. We are not standing idly by while rocket technology we pioneered is taken away just at the very moment its transfer to industry becomes profitable to the American economy.

For the past several years, the President and Congress have worked to create an institutional framework to enable the private sector to provide space launch capacity on a commercial basis, capacity that has become more precious in the wake of the *Challenger* accident. Of course, it was this commitment that led the President and the Congress, and this committee in particular, to direct the U.S. Government and DOT in particular to encourage private sector launches by expediting the approval process for commercial launch activities.

Our legislative charter sets DOT apart from other agencies involved in space. Unlike NASA, Air Force or NOAA, we are not in the business of building, launching or contracting for launch vehicles or services. Rather as with the other industries, we regulate. We develop effective policies and guidance that allow private providers of transportation to thrive, while ensuring that the public safety is protected.

Under Secretary Dole's leadership, we are working to create the conditions necessary to enable our U.S. private sector industry to be competitive. We are doing so in consultation with a broad cross section of the industry, launch vehicle manufacturers, satellite owners and operators, and the insurance and financial communities.

The establishment of an effective regulatory program is well underway. Interim licensing policies and procedures developed to implement the Commercial Space Launch Act, were published last year and will be published in revised final form this spring. We

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have been working with other agencies to resolve operational issues that are standing in the way of final commercialization and range use agreements. These agreements are motivating industry and Government to quickly focus on and quickly resolve a number of fundamental issues, the allocation of risk, the cost to commercial operators of purchasing services and facilities, environmental issue, and the overall issues that characterize any commercial enterprise.

We are mindful that a carefully implemented transition to full commercialization is essential. The executive and legislative branches must work closely to ensure that we have the appropriate incentives so that private enterprise accustomed to over 30 years of Government contracting finds it profitable to aggressively compete with other nations for commercial customers.

The U.S. Government will not compete with industry for customers but must work with industry to identify and work toward the removal of unnecessary barriers. We think such support is consistent with our charter, the President's policy and the best interest of the nation's overall space program.

Our view is and has always been that regulation constitutes the core of the Department's mission, ensuring that no aspect of commercial launch activities poses unreasonable safety risks to the public is our primary operational concern, and in developing effective safety requirements, DOT must conduct analyses of the same scope and depth as it does in other modes of transportation.

It is this effort that drives our fiscal year 1988 budget request. Our fiscal year 1988 budget anticipates the addition of two technical staff positions to assist in the direction of a research program and the evaluation of commercial launch license applications in addition to a request for $4 million to conduct the regulatory research itself.

The objective of our research program is to provide appropriate safety standards and criteria for commercial launch operators. At present, we see the need to develop a database of information specifically applicable to regulating a commercial space launch industry. These five major areas include R&D support and integration, technical support, environmental analysis, safety analysis and risk management.

The first area of contract support is a 1-year effort to provide the program planning and management necessary to carry out and aggregate the other aspects of the R&D initiative. The second 1-year contract will be let to provide near-term technical consulting services, identifying licensing issues related to commercial use of national launch facilities and services, and a task order contract will be awarded in the next 30 days to conduct a followup assessment of the environmental issues and to allow us to prepare alternate courses of action.

In addition, two larger multiyear contracts are being prepared in the areas of safety analysis and risk management. Safety analysis will focus on identifying public safety issues, assessing current range safety practices in the context of commercial launch operations, developing license evaluation criteria and the conduct of safety studies and data development.

Risk management contract work will identify those factors associated with new site locations affecting public safety, develop a da-

tabase and model for assessing the relative risk to public safety for each facet of a commercial launch activity, establish a means for interpreting findings resulting from license safety reviews, and for setting third party liability insurance requirements.

During this fiscal year, we will keep in close contact with the committee to discuss our contracting and research plans and to share with it the preliminary results of those efforts. Already some products, such as a programmatic environmental assessment and analysis of the licensing issues for launches for national ranges have been completed.

This environmental assessment is an excellent example of an effort in which we use existing data accumulated at the national ranges to meet a wide array of Government information requirements related specifically to commercial ELV operations. In addition, we have initiated a study of the generic hazards of commercial space activities that will provide a basis for analyzing the need for certain Federal regulatory actions.

Secretary Dole has directed me to assess the resources currently available to the Office of Commercial Space Transportation and to develop and execute a plan to ensure that we are able to respond effectively and in a timely fashion in carrying out our regulatory responsibilities. That plan is under development but I expect to be in a position to share it with the committee in the very near future.

Mr. Chairman, American firms have the resources and the capabilities to be successful competitors in the international market. By fulfilling our commitment to implement the President's policy and specifically the provisions of the Commercial Space Launch Act, we can create the conditions necessary to enable U.S. companies to compete in the international market and to reduce the backlog of satellites awaiting launch.

After nearly 4 years of effort, a policy framework is in place that establishes the basis for successful commercialization of space transportation and with continued congressional support, we will be able to work with industry to put our domestic ELV's to work in an increasingly competitive international marketplace. The result, I believe, will be a stronger, more resilient space transportation capability that we are all working toward.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Stadd follows:]

Statement of

**Courtney A. Stadd**
Director, Office of Commercial Space Transportation
U.S. Department of Transportation

before the

**Subcommittee on Space Science and Applications**
**Committee on Science, Space and Technology**
**U.S. House of Representatives**

March 11, 1987

Mr. Chairman, members of the subcommittee, thank you for the opportunity to report on the status of the commercial space transportation initiative. To date, domestic ELV manufacturers have signed over a dozen launch reservation agreements with satellite customers. I am pleased to announce that Martin Marietta has submitted mission review requests for two payload customers and that we expect to receive a third request from another launch firm soon. American Rocket Company has just initiated a licensing request for a test launch to be conducted later this year.

The response of America's private sector has sent a clear signal to our foreign competitors: We are not standing idly by while rocket technology we pioneered is taken away just at the very moment its transfer to industry becomes profitable to the American economy.

For the past several years, the President and the Congress have been committed to creating an institutional framework to enable the private sector to provide space launch capacity on a commercial basis -- capacity that has become more precious in the wake of the Challenger accident. It was this commitment that led the President and Congress to direct the U.S. Government -- and DOT in particular -- to encourage private sector launches by expediting the approval process for commercial launch activities, among other initiatives.

Our legislative charter sets DOT apart from other agencies involved in space. Unlike NASA, Air Force, or NOAA, we are not in the business of building, launching, or contracting for launch vehicles or services. Rather, as with other industries DOT regulates, we develop effective policies and guidance that allow private providers of transportation to thrive, while ensuring that the public's safety is protected.

Under Secretary Dole's leadership, DOT is helping to create conditions necessary to enable a U.S. private launch industry to be competitive. We are doing so in consultation with a broad cross-section of the space industry -- launch vehicle manufacturers, satellite owners and operators, and the insurance and financial communities.

In August, after serious study by Cabinet-level working groups, the President announced his decision to take the shuttle out of competition with private launch companies for routine commercial satellites. This Presidential decision was made in the context of a plan to provide affordable access to national range facilities, accelerate commercialization agreements between government and industry, include "commercial adaptability" as a factor in evaluating MLV proposals, and initiate interagency discussions to define the desirability and scope of international negotiations concerning fair competition in launch services. Most recently, the President included the commercial ELV industry as one element in the "Competitiveness Initiative," announced in his State of the Union Address.

The establishment of an effective regulatory program is well under way. Interim licensing policies and procedures, developed to implement the Commercial Space Launch Act, were published last year and will be published in revised final form this Spring. Also, we have been working closely with other agencies to resolve operational issues that have stood in the way of final commercialization and range use agreements. These agreements are

motivating industry and Government to focus on and resolve a number of fundamental issues -- the allocation of risk, the cost to commercial operators of purchasing services and facilities, environmental issues, and the overall issues that characterize any commercial enterprise.

Because access to existing launch facilities is absolutely critical to the industry, we are working closely with the Air Force and NASA to ensure that range use agreements are responsive to commercial launch industry needs and requirements. I asked our Commercial Space Transportation Advisory Committee to review a draft of the Air Force's model agreement covering commercial use of Government range facilities. A comprehensive analysis of the draft was prepared and submitted to both Secretary Dole and the Secretary of the Air Force. The report concluded that the draft was "overprotective of the government's interests" and should be rewritten with greater consideration to its impact on commercial enterprises. In particular, it pointed to liability provisions that could expose the industry to almost unlimited risks, uncontrollable costs, burdensome billing procedures, excessive demands for data disclosure, and monitor and control responsibilities beyond those required for assuring public safety.

Secretary Aldridge has told us that Air Force is now revising the agreement, largely based on the COMSTAC report to make the ranges more commercially viable. Some issues Air Force will be able to resolve on its own, while others, such as liability, will require government-wide involvement.

We are mindful that a carefully implemented transition to full commercialization is essential. The Executive and Legislative branches must work closely to ensure that we have appropriate incentives so that private enterprise accustomed to over thirty years of government contracting finds it profitable to aggressively compete with other nations for commercial customers.

The U.S. Government will not compete with industry for customers, but must work with industry to identify and work toward the removal of unnecessary barriers. Such support is consistent with our charter, the President's policy, and the best interests of the nation's space program.

The Department has actively worked to create an environment in which commercial space transportation can flourish. Our view, however, is and has always been that regulation constitutes the core of the Department's mission. Ensuring that no aspect of commercial launch activities poses unreasonable safety risks to the public is our primary operational concern. In developing effective safety requirements, DOT must conduct analyses of the same scope and depth as it does in other modes of transportation.

It is this effort that drives our FY 1988 budget request. Our FY 1988 budget anticipates the addition of two technical staff positions to assist in the direction of our research program and the evaluation of commercial launch license applications, in addition to a request for $4 million to conduct the regulatory research itself.

The objective of our research program is to provide appropriate safety standards and criteria for commercial launch operators. At present, we see a need to develop a data base of information specifically applicable to regulating a commercial space launch industry. The five major areas of study include: R&D Support and Integration, Technical Support, Environmental Analysis, Safety Analysis, and Risk Management. The first area of contract support (R&D Support and Integration) is a one-year effort to provide the program planning and management necessary to carry out and aggregate the other aspects of the R&D initiative. A second one-year contract will be let (Technical Support) to provide near-term technical consulting services, identifying licensing issues related to commercial use of national range

facilities and services. A task order contract will be awarded in the next thirty days to conduct a follow-up assessment of environmental issues and to prepare alternative courses of action.

Two larger multi-year contracts are being prepared in the areas of Safety Analysis and Risk Management. Safety analysis will focus on identifying public safety issues, assessing current range safety practices in the context of commercial launch operations, developing license evaluation criteria, and the conduct of safety studies and data development. Risk Management contract work will identify those factors associated with new site locations affecting public safety, develop a data base and model of assessing the relative risk to public safety for each facet of a commercial launch activity, establish a means for interpreting findings resulting from license safety reviews and for setting third party liability insurance requirements. Several other large contracts will be initiated in the fourth quarter of this fiscal year.

During this fiscal year, we will keep in close contact with the committee to discuss our contracting and research plans, and to share with it the preliminary results of those efforts. Already some products, such as a programmatic environmental assessment and analysis of the licensing issues for launches from national ranges have been completed. The environmental assessment is an excellent example of an effort in which we used existing data accumulated at the national ranges to meet a wide array of Government information requirements related to commercial ELV operations. In addition, we have initiated a study of the generic hazards of commercial space activities that will provide a basis for analyzing the need for certain Federal regulatory actions.

Secretary Dole has directed me to assess the resources currently available to the Office of Commercial Space Transportation and to develop and execute a plan to ensure that we are able to respond effectively, and in a timely fashion, in

carrying out our regulatory responsibilities. That plan is under development, but I expect to be in a position to share it with the Committee in the near future.

American firms have the resources and capabilities to be successful competitors in the international market. By fulfilling our commitment to implement the President's policy and the provisions of the Commercial Space Launch Act, we can create the conditions necessary to enable U.S. companies to compete in the international market and to reduce the backlog of satellites awaiting launch.

After nearly four years of effort, a policy framework is in place that establishes the basis for successful commercialization of space transportation. With continued Congressional support, we will be able to work with industry to put domestic ELVs to work in an increasingly competitive international marketplace. The result, I believe, will be a stronger, more resilient space transportation capability.

Mr. NELSON. Thank you, Mr. Stadd.

You are asking for in excess of $4.5 million in your request. This committee authorized $1.2 million for the current fiscal year, fiscal year 1987.

What is your estimate of how much you will have spent in fiscal year 1987? Not as of today; I'm talking about the end of the fiscal year.

Mr. STADD. To my knowledge, Mr. Chairman, we would have spent—to date, we have—let me start this way—we have obligated approximately $500,000 out of the $645,000 appropriated for contract work to date.

If I may defer for a second to be sure I answer you factually—let me be sure.

[Witness conferring off the record.]

Mr. STADD. Okay, he confirmed what I—that we will have obligated the entire amount by the end of this year, Mr. Chairman.

Mr. NELSON. Okay. So it's reasonable for us to expect that you will have spent $1.2 million for fiscal year 1987?

Mr. STADD. That is correct, sir.

Mr. NELSON. All right. You're going up in your request almost four times. Now, for example, you've got over $2.5 million for planning and development, primarily in safety research and analysis. Part of what you just told us, your safety analysis and risk management is assessing current range safety practices in the context of commercial launch operations.

Well, my Lord, down there in the Range Safety Office, they have to be—which is a continuing thing, with military rockets, with manned space flight and so forth, you know, they've got a pretty much operative, functioning.

Why do you have to go $2.5 million for that?

Mr. STADD. Mr. Chairman, as a regulatory agency, we have to be in a position to respond to a broad range of applications. This ranges from, in the one instance, an entity that has used the ranges, that will be using the established services and support capabilities at the range, to an applicant who comes in and wants to conduct a commercial operation at an entirely private site or an applicant who comes in and wants to conduct a commercial operation, but wishes to do much of the safety—or much of the operation by itself.

So we have to be smart in the Department in terms of being sure that the terms and conditions for the licensing are responsive and that the safety standards that we set forward are equally responsive, so that the Secretary an make an intelligent decision.

Mr. NELSON. I don't think you've convinced me, not four times the present amount.

Mr. STADD. Let me add in that regard, Mr. Chairman, as I understand it, when we first came in in fiscal year 1986, as I recall, we, in fact, had anticipated this growth in the regulatory research effort. I am told that we did have a reduction on the order of two-thirds last year, so that the leap, the apparent increase from that standpoint is actually not as great in terms of where we thought we would be, going back two years.

Mr. NELSON. Well, now, to the contrary. Let me refresh your memory.

What was authorized 2 years ago was about one-half of a million. What we authorized last year, which is this present current year, was double that, $1.2 million.

Mr. STADD. Again, what I'm—again, this is before my watch, but what I have been informed is that, in terms of the planning horizon for the office, that this number was consistent with that horizon, going back to a couple of years ago.

Mr. NELSON. Well, you talked about private launch sites.

Mr. STADD. Yes, sir.

Mr. NELSON. What companies are planning private launch sites?

Mr. STADD. Well, a number of entities have expressed an interest. Most recently, I have been informed that the State of Hawaii has expressed an interest in putting aside acreage for a private site, and, in fact, I'm informed that they're even considering—their legislature is even considering submitting a Space Authority Act to set up this facility.

I have heard on a very informal, proprietary basis from some other companies an interest in being able to establish a private site, but not for a number of years.

Mr. NELSON. Okay. So the question, then, is how many proposals do you presently have pending before you for private launch sites, and the answer is zero.

Mr. STADD. That is correct. But if I may follow up, sir, as you know, when—we need at least a couple of years to be in a position again to respond in a sophisticated manner to such a proposal, and it is our judgment, again per other—looking at the other regulatory activities in other parts of the Department, that regulatory research is a dynamic activity, and you need to start now in order to be in a position to respond to such an application, be a year, two, three or four years from now.

Mr. NELSON. I think what you're going to find, as you get into your regulatory research, is that most of the launches that you're talking about, at least for the forseeable future, are going to be equatorial launches, and they're going to be launched from the eastern test range, and you're going to find in your, quote, "regulatory research" that so much of that research is already existing, because, indeed, that's what the place is set up for.

Mr. STADD. Mr. Chairman, let me give you an example. I referred in the testimony to an environmental assessment that we had conducted, and I have a copy here.

This information on the environmental impact, if you will, of commercial operations at the ranges is based on data that was available at the ranges, but was not organized in a fashion that would have been responsive to the Environmental Protection Agency. It would not have been responsive to EPA requirements.

So what we did over the past fiscal year was to take that data and to profile it in a way that was responsive to the EPA. That is, I think, a concrete example of where you have the information, but again it's not organized, packaged in a way that is either addressing the regulatory needs of certain Government agencies or is not responsive to the commercial needs of the industry.

Mr. NELSON. Well, you know, I'm going to ask you the tough questions, because somebody needs to ask you the tough questions.

Mr. STADD. Of course. Yes, sir.

Mr. NELSON. We started launching—"we," the United States, started launching in the early 1950's. Now that's in excess of 35 years of data. And it sounds like, to me, that what you all want to do is to set up a staff to go out there and reinvent the wheel.

Mr. STADD. Mr. Chairman, if I may be personal for a moment, I come from the private sector, and I have worked in businesses that have been often the beneficiary but also the victim of Government's best intentions. I can assure you, speaking for myself, I have no intention of contributing to reinvention of wheels or redundancy at the expense of this industry, and I think to do so would be totally inconsistent with the Commercial Space Launch Act.

Let me add, as you've indicated, many, many, many years of launches from the ranges. In fact, I believe it is that experience that makes us competitive as I think we will be in the market. But when we talk commercial, we are talking about a shift in roles. We are talking a situation in which formerly the Government was both the range and the launch operator. When we talk commercial, we talk about the Government, at least at the National Range, being the range operator, and now we have a commercial component. We have a Company X coming to the range and saying—very much entering into a tenant/landlord commercial arrangement, if you will.

And that introduces not only a new set of roles, but a new set of issues that we have to be responsive to.

Mr. NELSON. Well, you know, one of the great things about what Pete Aldridge has done is that he is making, through his RFP, a commercially viable launcher of the Delta payload class, and for the purposes of the Air Force, there's going to be a pad there, and so that if it is commercially viable, which I assume it will be—I certainly hope and pray that it will be—you're going to have all of this vast experience of launching Delta II's from Cape Canaveral Air Force Station, of which there is going to be the same pad or pads.

So why, putting another layer of bureaucracy on top of all this?

Mr. STADD. Well, in that case, the actor in this case, McDonnell Douglas, again is entering into a commercial relationship with the range operations. And as I say, McDonnell Douglas may—and I don't want to prejudge how McDonnell Douglas wants to characterize its approach to range support, but let's suppose that they do simply take what's available to them—in that case, it's a very straightforward proposition.

McDonnell Douglas comes in with the licensing action or launch safety review action, and their application evidences that they are using established practices and procedures at the range, again without prejudging action on that item, we would be predisposed to expedite that application and move it on very quickly.

Mr. NELSON. Well, I would certainly think so. I mean, it's the Air Force who is basically drawing the agreement, so that the use of Air Force facilities will be facilitated.

Mr. STADD. Yes, sir.

Mr. NELSON. So that we can get a commercial launch business going.

Mr. STADD. Indeed. We are in total agreement with that.

Mr. NELSON. So what's the big deal for $4.5-plus million?

Mr. STADD. Well, again, in that particular instance, there may not be that big a deal, but at the same time, we have to be smart enough—and I think we are at this point, if somebody came in with that type of application—to respond to it.

If there is a problem, an accident or whatever, and the Secretary of Transportation has put his name to that license, you know, we have to be sure that in the followup investigations and so forth, that we did our part to ensure that that was a safe activity.

Having said that, I think that there shouldn't be a big deal attendant on that type of application.

On the other hand, sir, I certainly—I know you personally have, I think, tremendous hopes for the space industry, and I think you, of all people, clearly hope that the industry will blossom in years to come, and we may be speaking more than——

Mr. NELSON. Well, we all do.

Mr. STADD. Of course, sir. And I think that rather than—some people will take a snapshot of the industry as it exists today and sort of extrapolate in linear fashion to where it may be in the 1990's, I think we all hope that what we will see is a proliferation of different types of vehicles, configurations, and so forth, and, in fact, may see a push toward private launch sites, perhaps sooner than many people expect.

I don't know. All I know is that I think we need to have that type of regulatory research capability in hand, so that when somebody does come to us with an innovative concept, it's equally not a big deal to us, so that we can handle it as quickly as we might handle somebody who comes in with a more pedestrian type application.

Mr. NELSON. You know what your ultimate boss says? Your ultimate boss——

Mr. STADD. I'm always interested in what she says [laughing].

Mr. NELSON. No. Your ultimate boss is not she. Your ultimate boss is the President.

Mr. STADD. The President, right.

Mr. NELSON. What your ultimate boss says is, "Get government off our backs."

Mr. STADD. Yes, sir.

Mr. NELSON. And what you're imposing here is another layer of regulations when, in fact, you have a beautiful system set up with which to streamline and to make more commercially viable commercial launchers. And we're going to look very, very carefully at this, that Government is not going to impose another set of bureaucracy.

Mr. STADD. Mr. Chairman, you should. I mean, that's certainly the criterion that I'm held to at the Department.

Let me remind us that one of the reasons behind the establishment of this office was the fact that when space launch companies expressed an interest in going commercial a few years back, they found that they had a very enthusiastic reception from the Government to the tune of a dozen or so agencies that wanted to get into the act.

I think that we have worked very hard to ensure that when a given launch company has an interest, they have one place to go to, one place to be held accountable, that could be held accountable

in terms of responding to their needs, so that you know that you have one place, not an Air Force office somewhere off somewhere or a NASA office somewhere, you have one place that you can come to and say, "How are you handling this application, and can you explain to me why the delays?"

But I do want to stress with you that we have worked very diligently, I think, to make the process as streamlined as possible, and at the same time ensure that we are smart enough that we can respond to the whole range of launch applications that we expect.

Mr. NELSON. Let me give you an example.

Mr. STADD. Yes, sir.

Mr. NELSON. In the documents justifying your request, you are estimating 12 launches in 1987 and 1988; is that correct?

Mr. STADD. No, sir. Let me qualify that.

We are aware of at least 12 reservations, but we do not have, aside from these two licensing actions that I referred to earlier, three if you include the test launch—we do not have any specific licensing applications that lead me to tell you that there will be 12.

I am aware of interest on the part of the industry to conduct as many as half a dozen during fiscal year 1989. But you are aware that it takes a couple of years for companies to get their production line, start producing their—put the vehicle on operational status to launch their customers, so the licensing action often will begin one or two years in advance.

To answer your question specifically, we have these initial licensing applications, but I'm not in a position to say how many are to be anticipated in 1989.

Mr. NELSON. Well, I'm going to read to you from your own document.

Mr. STADD. Yes, sir.

Mr. NELSON. Item No. 2, Travel: "FY '88 marks the beginning of the operational status of the Office's licensing and safety program. Projections of 12 launches to be licensed in FY '87 and '88 dictates the need for travel funds in this appropriation to conduct licensing reviews and to begin inspection and monitoring activities."

Mr. STADD. Yes. Again, we are led to expect that there may be as many as 12 at that time period, but I emphasize again that these are licenses that we are discussing and not actual launches.

Mr. NELSON. When would they be launches?

Mr. STADD. Again, to the best of my ability, and again, I know you want me to deal in facts and not idle speculation, but my best informed speculation would be fiscal year 1989. I am aware of at least one company that has a slot reserved for very late 1988.

Mr. NELSON. A slot on what? What launcher?

Mr. STADD. Sir, if I may, I would like to keep that proprietary. I would be happy to share that with you——

Mr. NELSON. Well, I can tell you it is not the Delta Two. Everybody in this room knows that it is not the Delta Two because the Delta Two isn't even going to be ready for the Air Force until 1989.

Mr. STADD. As I say, it was given to me on a proprietary basis, but I am aware of at least one booster with a slot for late 1988. But I say fiscal year 1989, which, of course, covers the latter half of 1988, 1989.

Mr. NELSON. Well, I don't think you have demonstrated to us the licensing activity that you are talking about in these 12 launches because the 12 launches just aren't there.

Mr. STADD. Well, I think that right now we are aware, as I said, of a minimum of 12 reservations with deposits. We have received two requests for licensing actions. Once the range use agreements, those issues are resolved, the issues that have been referred to earlier, I am optimistic—in fact, let me quote one of the booster applicants to the effect that once these issues are resolved and we can "firm prices," that the "floodgates" will open and we will see a substantial increase in licensing actions.

That is the best I can respond at this point.

Mr. NELSON. If you can convince me and if you can convince Bob Walker that this is needed for the safety and indeed the encouragement of a commercial launch industry, the two of us are going to back you to the hilt because that is what we want to see in this nation, but we are not coming around and supporting a 400-percent increase in a budget of which there is no substantive fact for all the increase in the workload. It just boils down to that.

Now, you are going to find that we are straight shooters and we will shoot with you straight, and that has been one of the problems that we have had in the past, as you well know, is that your agency—not until Mr. Brumley got hold of it, and I give him credit, he has done an admirable job—not this Brumley. I am talking about——

Mr. STADD. Mr. Burnley.

Mr. NELSON. Burnley. Jim Burnley. Once he got into the act, things really started to straighten up, and I give him full credit for that. But, you know, you just haven't demonstrated to us that you need all of this extra Government help for this private industry because the activity is just not there.

I wish it were. I wish you had people waiting in line so that you could start processing these applications, but the fact is that they are not there.

Let me ask you this. You have got some items here under commercial applications R&D. I beg your pardon. That is the wrong one.

Let me ask you about—Chris, you just jump in any time you want. I have got a couple more questions here, so just jump in whenever you want to.

Mr. PERKINS. I will ask now if you want me to.

Mr. NELSON. Go ahead.

Mr. PERKINS. I think one of the questions that a lot of us have is obviously you are talking about a world competitive market when we are dealing with the ability for ELVs to get up. The American companies have a variety of vehicles at this stage, I guess the Delta, the Titan, the Centaur. The Chinese have the Long March and, of course, the Ariane, I guess, is the leader, probably, at this time.

How do you feel that the United States competitively versus all these other interests around the world is able to compete, particularly with the subsidized industries that you have in China and France? What does it cost for a launch in the different countries that we are talking about?

Mr. STADD. That is a very good question, Congressman. In fact, in listing some of the factors that I think make our industry competitive, I think I am also maybe responding at least in part to the chairman's concern about where the action is because I think these factors will, in my judgment, optimize the environment so that our industry, in fact, will be moving out very aggressively, very quickly.

In assessing the competitive standing of our industry, people tend to look at price. As you know, in the business world price is often less important than what the terms of the financing are. In fact, by anecdote, I recall at least one occasion when the French Ariane outcompeted the Space Shuttle even when the Shuttle had a cheaper price. Why? Because the French had more competitive terms. They allowed the customer to put only a certain amount of money down, pay out over time as their satellite showed a revenue. Very classic Marketing 101.

That is the first thing. I think in our industry, if any industry in the world has the ability to be innovative——

Mr. PERKINS. Let's start with price. Granted there are always situations where you have a better financing package.

Mr. STADD. Sure.

Mr. PERKINS. Let's start with price, and you can elaborate on the financing packages.

Mr. STADD. Yes. But I would like to add another thing. This is very important to the competitive standing of the industry. First of all, the industry can offer a competitive price. They have told us that they are not concerned. Industry has not been coming to us and fretting about competing head-on pricewise, with Ariane in particular. They feel that they can be competitive.

In particular there is the exchange rate. People often neglect the fact that the French have benefited from a rather high dollar value the last few years. In the last year or so, as you are all aware, we have had a low—the dollar value has been decreasing, which has made the French system all the more uncompetitive with our systems.

In fact, I have seen some remarks from Ariane officials expressing a bit of consternation about the ability of MAC DAC to compete in the $30 million range, which is what MAC DAC has been claiming. The French equivalent would be on the order of about $40 million, so just in terms of the types of prices being quoted right now, the French—we can offer competitive rates.

A fundamental factor in our favor is reliability. The systems that we are talking about, at least in the near term, the Martin Marietta Titan, Atlas Centaur, TD, and of course, the Delta system by McDonnell Douglas are established systems and they have enviable reliability rates, upward in the nineties, important if you are a customer because the customer is not in the business of obtaining insurance after a loss. You are in the business of obtaining revenue.

Mr. PERKINS. How many launches did the Ariane have last year?

Mr. STADD. I would have to go back and check.

Mr. PERKINS. Do you have any idea of a ballpark figure?

Mr. STADD. I may be wrong, but I am tempted to say seven or eight, but I may be wrong. And of course, they had one failure last year.

Mr. PERKINS. And you don't know what the price on those launches was last year?

Mr. STADD. Not offhand I don't, sir. I can provide that to you.

Mr. PERKINS. Well, what kind of price are the Chinese offering?

Mr. STADD. The Chinese have been offering in the range of the twenties, upper twenties.

Mr. PERKINS. Compared to the forties that we are offering?

Mr. STADD. Well, you have to compare, of course, apples to apples. In the case of the Delta you are talking approximately in the thirties. Again, I hate to even discuss price because it is the companies that have to make that judgment call, and sometimes a company will be able to package a deal in a way that comes in even at a different price.

Mr. PERKINS. I understand, but always price has got to be one of the initial things that you look at when you are trying to put something up into space. Reliability obviously comes in, financing obviously comes in, but in terms of the overall price, that is a good place to start.

I mean how are we being competitive in terms of price with the Ariane, with the Chinese satellite, which yesterday we had someone testify here that there were three American satellites that were going to be placed into orbit by the Chinese with their Long March, so obviously something that they are doing is hitting a responsive chord with some of the American customers.

So if it is not price, if it is—you say reliability, you say——

Mr. STADD. That is very important.

Mr. PERKINS. But obviously they are selling with something. Is it price that they are selling with? Give me some of the other variables.

Mr. STADD. Let me stick, if I may, with reliability for a moment. The Long March is a new vehicle and they have had three launches and they have had one failure. Of the three that you have indicated, I am aware of two contracts, one with a company called Teresat. That company has entered into a contract to launch the Weststar, and quite frankly, Western Union, it is no secret, has been financially strapped and desperate to seek any alternative that is reasonable to get that system on orbit.

The other one is the Pan American Pacific. There are only reservations, I think, for the American satellite are Dominion Video.

I think the Chinese have devoted a great deal of time to trying to make themselves as attractive as possible. They really have not been all that successful, especially if you look at the fact that customers really have not had that many alternatives to date, and the Chinese have had to bend over backward to try to make it as attractive as possible.

We still have export control problems. We are still looking at these applications in the Government on a case-by-case basis, and as I say, and I want to repeat this, I am hearing this from the bulk of the American satellite customer base, that they would prefer to deal with a system that is more reliable, and without being pejorative to the Chinese, prefer to deal with people whose primary language is English.

So there has not been a great deal of enthusiasm, from what I have seen, for going to the Chinese irrespective of what appear to be fairly attractive prices and fairly attractive insurance terms.

Mr. PERKINS. Taking those biases, from what I have heard here earlier, you are talking about maybe 12 American launches over the next short period of time, whatever it is. You say, well, that is not a definite 12, but whatever, you are talking about three Chinese here with all the problems that are associated with them, and then you are talking about maybe 12 American, which is——

Mr. STADD. I will go a step further.

Mr. PERKINS [continuing]. One-fourth the number. So obviously, there is something there that even with all the problems is very attractive to someone. I am just wondering on a realistic basis what type of ability do we have in the long term once the kinks get out of their system or anything else to take a $15 million differential between a Chinese vehicle versus getting an American vehicle, getting a satellite up?

Mr. STADD. I mentioned 12 because I want to be as conservative as possible. I am aware of discussions with the American ELV industry and customers involving as many as 20 reservations with American satellites, so the bulk of the customer base that has been looking for alternatives are still in discussion.

Mr. PERKINS. How many with Ariane right now?

Mr. STADD. I am aware of, I believe, as many as, I guess, a half-dozen that have been reserving with Ariane. Again, that is subject to getting back to you to be sure I have given you the right number.

So that I still stand behind my assessment that once we allow the U.S. industry to have the terms and conditions worked out for the ranges and allow them to make those firm prices, that (a) they do have competitive pricing, but (b) the reliability factor is overwhelming in terms of allowing them to overcome the Chinese.

There is another factor that I am missing here. I am assuming, and should not, that the Chinese have the production capability to respond. They do not. One of the constraints on the Long March production, of course, is the third stage, so there is a technical inhibitor that the Chinese have to overcome to respond significantly to the customer traffic.

Mr. PERKINS. What is the lead time in ordering the Chinese or the Ariane vehicle? I mean how long does it take for the rocket once you make an order to have it produced and be in production ready to send the satellite into space?

Mr. STADD. I assume typical production runs—again subject to ensuring that I am responding accurately to the French case. I know in this country you talk anywhere from 18 months optimistically, normally 24 to 30 months, to run a vehicle through the production line.

I think the French are capable of getting a rocket off the line between 12 to 18 months. But what makes it a difficult question is often you manufacture these vehicles in blocks, and you may well have one in the stable ready for putting it on line. So it is not always a question of you come in as a customer and actually want to sign a deal, that that means that I have to go out and start a new production run.

Mr. PERKINS. When you talk about reliability, that obviously brings up the other big factor that you are dealing with, and what ability do these other companies and countries have in terms of insurance? What kind of pricing are you talking about and what type of coverage are you talking about?

Mr. STADD. In the case of the French, they have put together a pool of insurance. If you will, they have bundled together a series of launches and then each of the customers have sort of bought in to an overall risk package. The rates that I have heard are currently about 14.5 percent. Informed sources indicate that the French premium rates for the second pool will probably be significantly higher than that. Again, the French have had their problems technically.

Mr. PERKINS. Versus what are the American rates?

Mr. STADD. The latest quotes that I have gotten have been somewhere in the twenties. We will have a better handle on that, Congressman, when Palapa goes out and seeks coverage, as well as Eutelsat and Aussat in subsequent weeks.

Mr. PERKINS. Somewhere in the twenties. You mean 25, mid twenties?

Mr. STADD. Yes.

Mr. PERKINS. So you are talking about ten-percent differential in rate?

Mr. STADD. Yes, but again, when you talk insurance, that also was an arcane field because there were different types of insurance packages.

Mr. PERKINS. I said what different types of coverages.

Mr. STADD. But it would be fair to say that, as an average premium, you are probably talking right now somewhere in the twenties, subject to a couple of factors. The capacity has been growing. If you had asked me the question about capacity a number of months ago, we would have been talking somewhere 80, 90 million. Latest information is upward of 120 million.

The recent successful launch of the Delta a couple of weeks ago has increased the confidence factor in the market. Assuming that the Palapa is successfully launched later this month, that in turn will increase the capacity of the market. That in turn will have a favorable impact on the premium.

As you know, it is a dynamic field.

Mr. PERKINS. It is a dynamic field, but what we are seeing right now with the French is about 10-percent difference in rates, subject to these other things.

How about the Chinese?

Mr. STADD. The Chinese, again subject to the fact that—ensuring that I'm giving you the right facts, I guess have been quoting somewhere in the early teens, but our companies, at least two of them that I can think of, have been offering a free reflight to the customer, so that that helps offset some of the premiums that other people are offering.

Mr. PERKINS. So presently, from what I have heard, we have a difference in price and in insurance. How about financing packages per se? What's—how do the three compare in that regard?

Mr. STADD. It's difficult to say. We won't be in a position to respond to that until we overcome the next hurdle, and that hurdle

is the terms and conditions for use of the national ranges, and Mr. Gilliam testified earlier about his activities in that regard, and once the privatization agreements that NASA is working on are completely finalized, once the range use agreement the Air Force is working on is finalized, we then have the basis for our companies to provide firm price quotes. They don't have that, the cost information necessary for that type of firm price quote, so they can give to the customer to allow a reservation with deposit to become a final contract. So it's premature, unfortunately, it is premature to respond to your question.

Mr. PERKINS. So it is premature to know the financing, and right now we have a problem with the insurance and a problem with the cost. It doesn't seem like we're getting off to a great start here in terms of——

Mr. STADD. I'm not giving the right impression.

Mr. PERKINS. Oh.

Mr. STADD. There is no indication that the market mechanism and the insurance industry is broke. There is every indication that the insurance industry is making strides in responding to a commercial launch world, and it isn't until you get down to cases that one can really begin to, you know, respond to the level of detail that you're asking. But in terms of where we stand, Congressman, since August when the announcement regarding payload priorities was made on the Shuttle, in industry both the booster people as well as, more importantly, perhaps, the customer people finally were convinced that they had to look for U.S. private sector alternatives.

In the months since that announcement, there's been terrific progress. Mr. Gillam has indicated that he is very close. In the case of General Dynamics, your committee handled—reacted very expeditiously in reviewing that particular agreement. That was signed.

In the case of McDonnell Douglas, it's very close to being signed, with NASA.

The case of the range use agreement with the Air Force, our advisory committee had problems with it from a commercial standpoint. We felt it was a commercially unreasonable document in December, and I can say as of today that we are very close—I'm talking within a couple of weeks—of finalizing that particular agreement. I believe—I don't want to speak for the Air Force, but I'm very optimistic that that agreement can be finalized. I am optimistic that in very short order we will have the terms and conditions in place for the industry, our industry to, as I say, go for reservation agreements with deposits to final contract.

In fact, given the environment, given the fact that even in the absence of these final issues to be resolved, I have been very impressed with the level of serious negotiation between customers and the ELV boosters. I have mentioned over a dozen reservations that I'm aware of.

As I said earlier to you, I'm aware of close to 20 that are in the signing stage, and if anything, I have been accused by the industry of being a bit too conservative in my remarks to the Senate last week.

Mr. PERKINS. Just out of curiosity, are these reservations that you're referring to all American reservations?

Mr. STADD. Some of them are not. The bulk of them are American. That is correct. There are—I can think of three, perhaps four, that are foreign.

Mr. PERKINS. How do we——

Mr. STADD. But I may be off on that, because——

Mr. PERKINS. How do we appear to be stacking up in terms of drawing foreign business?

Mr. STADD. I think we are doing very well. I mean in fact, I'm not aware of a foreign entity that we have approached that has not been willing to sit down and talk very seriously with U.S. ELV companies. So from my standpoint, we are doing very well.

Mr. PERKINS. But you don't have the numbers? Do you have the numbers put down in terms of reservations at this point?

Mr. STADD. I do not, because again much of that is proprietary, but I am aware, just based on conversation with the industry of some of these negotiations.

Mr. PERKINS. Do you have any kind of ball park figures? I realize you are talking about proprietary type things, but——

Mr. STADD. Well, I've given you what I'm aware of, and I'm aware of four that are inactive—that are at the reservation agreement stage.

Mr. PERKINS. Now we have been talking about reservations, and you know, that's good. Now in terms of the actual signed contract, how many are we talking about?

Mr. STADD. No signed contracts. The signed contracts are waiting for these terms and conditions that I referred to earlier. What you have are reservations that——

Mr. PERKINS. How about signed contracts for——

Mr. STADD. No, what you have are——

Mr. PERKINS. No one has any signed contracts?

Mr. STADD. No, sir. We have a reservation agreement that says that the company and the customer have agreed to enter into a final agreement. There is a $100,000 good faith deposit on many of them, in some cases $50,000, and conditioned on——

Mr. PERKINS. But the Ariane doesn't have any signed contracts of this type?

Mr. STADD. Oh, they have signed contracts; yes, they do.

Mr. PERKINS. How many do they have?

Mr. STADD. I'd have to get back to you. I don't have the number on that.

Mr. PERKINS. Approximate?

Mr. STADD. I'd have to get back to you. I don't know that.

Mr. PERKINS. So they do have signed contracts. Do the Chinese have any signed contracts?

Mr. STADD. Sure do.

Mr. PERKINS. They do?

Mr. STADD. Yes. Because, in both cases, you have foreign entities that are in a position to—they know what their costs are at the range, so they can quote firm prices. Our big hangup at this point is that we haven't completed our end of the bargain with the industry to allow them to do that.

Mr. PERKINS. What kind of timeframe are you talking about with getting the information on the ranges?

Mr. STADD. Well, this is Courtney Stadd's timeframe, and I think, I know, I speak for the Department. We want to get this finalized in the next couple of weeks. I'd like to say by the end of the month. We have suggested to NASA and to the Air Force, and they have responded positively to this invitation, that we sit down—I think that's consistent with our mandate as a facilitator that we encourage NASA, Air Force to sit down at a meeting and have a meeting of minds and ensure that we come to closure on all these agreements quickly.

Mr. PERKINS. So then we'll be ready by April 1 to be able to sign contracts?

Mr. STADD. It would be my hope that we would be in a position very soon to do that. You say April 1st. I can't be held to a date because I can't speak for Mr. Gillam's agency or Secretary Aldridge's. But it clearly—it is our intention—and let me say that we are being pushed very hard by the U.S. ELV industry to allow them to be in a position as soon as possible. I have been, as recently as a week or two ago, have been urged by one of the major booster companies to do everything we can to come to finalization of these issues by the end of this month. So April 1, that would be a hoped-for date. All I can say to you, sir, is that we are committed to say as soon as possible.

Mr. PERKINS. Following your ability to sign contracts, not—how long do you anticipate that it will take for you to finalize your first several agreements? Your first agreement?

Mr. STADD. How long would it take for the industry to finalize their reservation agreements? Well, to hear the industry talk, in some cases, 24 hours. I mean we're that close. Clearly you'll need some time because the customer has to react to it and you have some negotiating time, but in terms of timeframe, very quickly.

Mr. PERKINS. How many do you have that close, just a ball park figure?

Mr. STADD. I—again, this is ball park, but I would say between 16 and 20. Again, based on information from the industry to date.

Mr. PERKINS. Okay. I thank you for your patience.

Mr. STADD. Thank you, sir.

Mr. PERKINS. Mr. Chairman, I yield back the balance of my time.

Mr. NELSON. Mr. Stadd—is it Stade or Stadd?

Mr. STADD. No, it's Stadd.

Mr. NELSON. Stadd.

Mr. STADD. Yes, sir.

Mr. NELSON. Like S-t-e-d?

Mr. STADD. S-t-a-d-d, sir.

Mr. NELSON. No, I know it's S-t-a-d-d, but you pronounce it like Stead, S-t-e-a-d.

Mr. STADD. That is correct, sir.

Mr. NELSON. All right. I have a letter here to you from the Attorney General's Office in which we are talking about insurance here.

Mr. STADD. Yes, sir.

Mr. NELSON. It says, "Therefore, the government shall bear the risk of accidents caused by its own negligence. Accordingly, the Department of Justice generally agrees with your suggested indemnification provisions, which would make each party responsible for damage caused by its own negligence."

What happens if a rocket is negligently assembled and falls in the middle of Coco Beach?

Mr. STADD. It's comparable, Mr. Chairman, to a 747 colliding with another 747 over New York. Boeing Corp. would have to assume that—and its carriers would have to assume that responsibility.

In addition, clearly there would be an investigation to assume—to determine whether the U.S. Government or the air traffic control system, in the case of a 747, was at fault. We have that similar investigation going on with the Air Mexico situation. So in the case of the rocket landing on Coco Beach, if it in fact is found that the manufacturer is culpable, the manufacturer would have to pay.

Mr. NELSON. Do you think—well, then, you do not see that as an impediment in encouraging folks like McDonnell Douglas to come forth and proceeding?

Mr. STADD. I do not, sir. McDonnell Douglas in particular on the aviation side is very much accustomed to organizing risk packages for fairly substantial exposures. So I don't see that as a fundmental impediment at this point.

Mr. NELSON. Well, what are the liability limits that you are talking about?

Mr. STADD. Well, we are currently reviewing that. Clearly the standard liability level has been $500 million, but I think our current situation is to assess that on a case-by-case basis. We have the fortuitous circumstance of having an extremely successful claims record, by and large, in the launch industry, and—but I'll say 500, but I will say that the level would really have to vary based on the individual determination.

Mr. NELSON. And that's what you're thinking of, a limit of 500 million?

Mr. STADD. Yes. I wouldn't want the record to reflect that that is in concrete, but that is clearly—has been a guiding standard based on NASA's assessment. But that is something that we would have to assess on a case by case. I wouldn't want to make a regulatory determination. In fact, the attorneys at the Department warned me about making that type of regulatory determination in public. But I think it's fair to say that would—that might well be a ball park. But again it might be much lower, depending on the application.

Mr. NELSON. How do you square what you just said with the comments on the draft by the Air Force, the draft is entitled "Expendable Launch Vehicle Commercialization Agreement," and the comments to the Department of Transportation by Alan McArter, who was the chairman of this advisory committee on commercial space transportation, in which Alan says the draft agreement—that being the U.S. Air Force draft agreement—exposes the commercial operator to unreasonable, almost limitless risk? It says as written the commercial operator would have to bet the company on each launch.

Mr. STADD. Yes, sir.

Mr. NELSON. How do you square that with what you just said?

Mr. STADD. We have—in going back and reviewing the contract, we have been walking a line, a fine line, between addressing the industry's concerns about betting their company, about the one-sided nature of those liability provisions, and the trend that we are

all familiar with in this Government of limiting liability to the Government itself.

We think that what we are working on is a compromise, and we are still working out the details, Mr. Chairman, to share the responsibility, so that as Ike referred to earlier, if a commercial operator is utilizing Government property and damages that property, clearly that operator should bear the risk for it.

On the other hand, if the Government is culpable, if the Government, through some mishap or through some fault of its own, contributes to an accident or whatever, clearly the Government should bear that responsibility. So we are looking to allocate the risk in a way that doesn't put the total burden on the industry, but puts the—what we hope will be the equitable part of that burden on the industry.

Mr. NELSON. Well, you told us about a limit of 500 million.

Mr. STADD. Ball park. That's not—yes.

Mr. NELSON. Do you have a rulemaking planned?

Mr. STADD. Do not. We are, in fact, going back to the earlier discussion about the research program. That is one of the efforts of that program, is to give us the information that we need to make that type of determination.

Mr. NELSON. What do you see as a major impediment or impediments to commercialization of ELVs?

Mr. STADD. Well, for the moment, Mr. Chairman, I think the biggest impediment are what appear to be pretty pedestrian, but I think are pretty profound from a business planning standpoint, and that is addressing Congressman Perkins' point, the terms and conditions.

Right now the industry does not know how much it costs to use the services at the ranges. We need to nail that down, and the monkey is on our back, NASA's back, Air Force's back, to move real fast to provide that information, because that information is a large contributor to their profit margin.

Mr. NELSON. Who is yanking you around on that? Pete Aldridge told me that he was going to have basically those launch services offered at cost. That was the impression I was under.

Mr. STADD. Yes. He is making every effort to do that. The—what we are down to is taking, for example, the direct cost concept, Mr. Chairman, and that's been discussed at length in this committee and previously, and translate that into chargeable items—in other words, break down, itemize what the individual services and support services that are being made available to the industry, what those chargeable items will be. And we are still in the process. A lot of progress has been made on that front, and as I say, I think we are very close to getting that nailed down.

But that process, Mr. Chairman, did not begin in earnest until the fall. In fact, we did not have a meeting involving the ELV manufacturers, the communications satellite people, the financial people, with NASA, Transportation and Air Force until December. That is, that was the first full scale meeting, if you will, at Patrick Air Force Base. That symposium was a major catalyst in hearing the complaints of the industry, the needs and concerns of the industry, and then we spent January, or the Air Force spent January

and February going back and going through another series of iterations to respond directly to industry needs.

Mr. NELSON. Chris, do you have any further questions?

Mr. PERKINS. No, I don't.

Mr. NELSON. Mr. Gillam, do you have any questions of Mr. Stadd?

Mr. GILLAM. No, sir.

Mr. NELSON. Mr. Stadd, do you have any questions for Mr. Gillam?

Mr. STADD. No. Just that I look forward to working with Ike after this meeting and be sure that we get the range agreements and everything signed, so that I can come back to you and show you that the floodgates have opened up and put you in the position where you may ask whether this is enough money for us to sustain a regulatory research program.

Mr. NELSON. All right. Mr. Brumley, would you come up?

You guys just stay right there. We're going to get a roundrobin going here pretty soon.

Okay, Mr. Brumley, we'd be delighted to hear from you.

## STATEMENT OF ROBERT H. BRUMLEY, DEPUTY GENERAL COUNSEL, DEPARTMENT OF COMMERCE, WASHINGTON, DC

Mr. BRUMLEY. Thank you very much, Mr. Chairman.

First of all, as I understand, the comments that we submitted for the record will be made a part of the record.

When I was originally asked to speak on behalf of the Secretary and the Deputy Secretary, we focused our comments on the Office of Commercial Space Programs, and on both Secretary Baldrige's behalf and on Deputy Secretary Brown's behalf, I would like to say that they very much appreciate the opportunity for the Department to come up and basically brief you as to an idea, a proposed office at this time, but hopefully an office that will not only develop into a functioning organization, but at the same time provide a real service to the private sector.

I am somewhat—before I talk about the Office of Commercial Space programs, I would like to—there's something of a historical note here. I look at not only the length of the table, but the three participants sitting here, and in terms of space and more specifically commercial space, I see something of a continuum represented here.

NASA for all its good service, 30, 40 years, and specifically its near-term service in stimulating private sector investment through their Commercial Centers has carried the ball on commercial space for a number of years.

The Department of Transportation's new office represents the future of a new space industry, one that, by the way, the President mentioned in his "Quest for Excellence" package that he sent up here, a commercial space transportation industry, and their office was established, as Mr. Stadd has already explained, to focus their energies on making sure that assured access in commercial terms will make space available to the average business person, who may want to consider space as part of his business plan.

That leads you to the Department of Commerce, because we deal not only with small and medium-sized and large firms, but with the average firm that may want to consider space or space services, whether they be transportation services or telecommunications services or services for the Weather Service, remote sensing, materials processing, or whatever they may want to do in space, as a new business sector.

And that, if there's any historical point here, Mr. Chairman, it's the fact that space now is a business sector, not just another business sector, but a business sector which is the concern of those who deal with business concerns, such as not just the Department of Commerce, but also other agencies in the Administration, the Department of Treasury, the Justice Department, the U.S. Trade Representative, the State Department, even the Labor Department, the Department of Agriculture and the Department of Energy.

We are all concerned that in this next business sector, we avoid the mistakes we have made so often in business sectors here on Earth, and at the same time, we create enough of a stable investment climate that American firms will be first in space, in commercial space, and be effective competitors when they're there, both in terms of services and products they manufacture for consumption in space or back here on Earth.

It's always bad to use an analogy or a phrase to catch that historic continuum, but I think more specifically history will prove that discoverers or explorers are always followed by the exploiters. Ike represents the explorers, and the best of the explorers. Courtney Stadd and the Department of Transportation and the Department of Commerce represent certain segments of the exploiters. We are there to do one thing. That's basic capitalism, and hopefully American business will go there and make money in space.

With that, we have decided to consider developing an Office of Commercial Space programs at the Department of Commerce to consolidate and not create new programs in the Department, but to consolidate the advice we are already providing to the business community, advice that deals with questions that have already been discussed here in some detail today—the affordability and availability of insurance, what is necessary and what is the proper role of Government in creating a stable investment climate, whether it's in the space business sector or even one here on Earth.

Those are concerns that the Department deals with on a day-to-day basis through the various operating units of the Department—the International Trade Administration, which is concerned not just with import administration and free and fair trade of products across borders, but also trade development, expanding trade into new business sectors such as space.

In addition, the National Telecommunications and Information Administration, that is our unit that deals with telecommunications policy, as well as represents the telecommunications industry within the Administration. Their voice, represented through the Secretary of Commerce at the cabinet table, speaks about telecommunications trade and the pitfalls and successes in that area.

In addition, we have the National Oceanic and Atmospheric Administration, NOAA. NOAA, in the past, has stimulated some form

of private investment in space as a procurer of systems made in the private sector for civil purposes, such as the weather satellites.

Now there is a policy decision at the Department to go one step further and support the Department of Transportation and NASA and the President's policy to procure commercial expendable launch vehicle services for launching the next series of GOES satellites.

In addition, we are continuing to work the contract problems on trying to privatize Landsat.

In addition to NOAA and NTIA and the units in ITA, which is not just the units that deal with aerospace, but also those that deal with science and electronics, they also deal with the service industries and service concerns, such as the insurance industry and the industries that provide services through that particular medium, such as international banking, attorneys, accountants, all of these individuals being involved again in potential investment opportunities in space.

Finally, the Patent and Trademark Office. The Patent and Trademark Office is worried and concerned, as is the International Trade Administration, that before we start making patentable products in space, we understand that the treatment of that intellectual property will be to the favor of the inventor, and that individual who had that innovation, so that he can, in turn, develop the commercial potential of that particular product.

So with all those units, we have in the past, and I would say for at least the last 20 years and now more recently within the last 5 or 6 years, have been counseling business, after they visit Mr. Gillam's office or after they visit Mr. Stadd's office and other offices that deal with space as a sector, and they come by the Department of Commerce to find out what is the current patent treatment on products manufactured in space, or what will the trade laws—how will the trade laws apply to anything I may wish to develop in space? What is the problem with affordability and availability of insurance? Can I manage the risk?

To capture all this in sort of a hypothetical, I draw on Congressman Walker's concept, which I don't think is really that farfetched, and that is ultimately the habitation of the hotel in space. He mentioned it to Mr. Gillam as to how—what services would NASA, through the Office of Commercial programs, provide in support of such a concept when a private-sector individual comes in to seek that support. And Ike appropriately answered, "In the area of technical assistance."

We will help you determine your environmental requirements. We will help you in terms of space architecture to develop the best habitation for what you wish to accomplish.

That individual, however, is going to have to make at least two more stops, we hope. One will be to the Department of Transportation with the support of NASA in determining what is the best launch capability to place that system in space, whether it be an ELV or whether it is Shuttle unique and will fly based on the available manifest capacity at the time.

Another place we would like that individual to come would be the Department of Commerce, this Office of Commercial Space pro-

grams, because there, the first question we're going to ask that individual is, how much do you want to spend.

The second question is, what do you want to do with it. What is your market? What's your demand? Do you plan, say, on having international participation in this particular venture, this hotel in space? If so, risk management, go to ITA, the Deputy Assistant Secretary for Service Industries. If it's in terms of manufacturing or any kind of light manufacturing you want to do there, you may want to stop by the DAS for Science and Electronics to tell you not just what we're doing domestically, but what our competitors are doing to us internationally. And number three, if it, in fact, is just a hotel in space, we also have the Travel and Tourism Bureau.

At the Department of Commerce, our concerns are ones that are the concerns of the business community. They are usually secondary or tertiary when you're dealing with the advancement into a new business sector, because the technology, the technical assistance, and the innovations, that is what draws most of the attention.

But ultimately, if there is going to be private-sector investment in space, there is going to have to be a stable investment climate, and in that investment climate will be the concerns of management, the concerns of the finance people, the concerns of the product people, the quality people, the distributors, the dealers, the international folks, those who deal with intellectual property, the attorneys.

We think at the Department of Commerce that the Office of Commercial Space programs can consolidate the current services that are being offered within the Department in a very small office with a Director at this time, a Policy Analyst, and a clerical and a budget of under $200,000, and in that office, instead of expanding into a larger, permanent facility at this time, we will draw on the experts, the career professionals in the department, who are already giving us advice, but focus their attention on space as the next business sector.

That's our hope. That's the desire of Deputy Secretary Brown and Secretary Baldrige, and I would be happy to answer any questions.

[The prepared statement of Mr. Brumley follows:]

STATEMENT BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

BY

ROBERT H. BRUMLEY
DEPUTY GENERAL COUNSEL
U.S. DEPARTMENT OF COMMERCE

MARCH 11, 1987

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE, ON BEHALF OF SECRETARY BALDRIGE AND DEPUTY SECRETARY BROWN OF THE DEPARTMENT OF COMMERCE, I WELCOME THIS OPPORTUNITY TO TELL YOU ABOUT THE DEPARTMENT'S PLANS FOR AN OFFICE OF COMMERCIAL SPACE PROGRAMS.

THE OFFICE IS STILL IN THE PLANNING STAGE. INITIALLY, THE OFFICE WILL BE ESTABLISHED IN THE OFFICE OF THE SECRETARY UNDER THE DIRECTION OF DEPUTY SECRETARY BROWN. WE EXPECT A BUDGET OF $180,000 FOR THE FIRST YEAR. THIS AMOUNT WILL FUND POSITIONS FOR A DIRECTOR, A POLICY ANALYST, AND CLERICAL SUPPORT. WORK WILL BEGIN AS SOON AS WE HAVE FOUND A QUALIFIED DIRECTOR, POSSIBLY EARLY THIS SUMMER.

ALTHOUGH WE ARE STILL PLANNING THE OFFICE, ITS GOAL IS CLEAR -- TO MAKE SPACE AN ATTRACTIVE ARENA FOR COMMERCIAL INVESTMENT BY INSURING THAT NO GOVERNMENT BARRIER OR ACTION UNNECESSARILY IMPEDES THE COMPETITIVENESS OF AMERICAN FIRMS IN THIS TRULY GLOBAL MARKET. WE ANTICIPATE AT LEAST THREE KINDS OF ACTIVITIES FOR THE OFFICE: FIRST, THE OFFICE WILL SUPPORT THE ROLE OF THE DEPARTMENT OF COMMERCE IN THE DEVELOPMENT OF THE ADMINISTRATION'S SPACE POLICY WITHIN THE ECONOMIC POLICY COUNCIL AND THE NATIONAL SECURITY COUNCIL. IT WILL ALSO TAKE THE LEAD WITHIN THE DEPARTMENT IN IMPLEMENTATION OF THAT POLICY. IN PURSUIT OF THE ADMINISTRATION'S POLICIES, THE OFFICE WILL DEVELOP DEPARTMENTAL INITIATIVES AND TAKE OTHER ACTIONS CONSISTENT WITH THAT POLICY. SECOND, THE OFFICE WILL RELY ON THE DEPARTMENT'S EXISTING LINKS

TO THE BUSINESS COMMUNITY TO ADDRESS THE CONCERNS OF THE PRIVATE SECTOR REGARDING THE COMMERCIAL DEVELOPMENT OF SPACE. FINALLY, THE OFFICE WILL COORDINATE THE GATHERING AND DISTRIBUTION TO THE PRIVATE SECTOR OF SPACE-ORIENTED INVESTMENT INFORMATION. UNDERLYING EACH OF THESE TASKS IS THE CENTRAL RESPONSIBILITY OF THE DEPARTMENT TO PROMOTE DOMESTIC AND INTERNATIONAL COMMERCE IN THIS NEWEST BUSINESS SECTOR -- THE DEVELOPMENT OF COMMERCIAL SPACE. NONE OF THESE TASKS IS INTENDED TO DUPLICATE THE EFFORTS OF SECTOR-SPECIFIC OFFICES AT OTHER AGENCIES, SUCH AS THE DEPARTMENT OF TRANSPORTATION'S OFFICE OF COMMERCIAL SPACE TRANSPORTATION. IN FACT, WE HOPE THEY WILL BE COMPLEMENTARY.

SOME OF THE SERVICES THE DEPARTMENT NOW PROVIDES RELATE TO COMMERCIAL SPACE ACTIVITY:

- TELECOMMUNICATIONS -- MANUFACTURING, OPERATING, AND SERVICING SATELLITES -- IS THE MOST DEVELOPED SPACE INDUSTRY. THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION KEEPS A CLOSE WATCH ON THE COMPETITIVENESS OF THIS INDUSTRY.

- THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, WHEN IT PURCHASES COMMERCIAL LAUNCH SERVICES FOR ITS NEXT GENERATION OF WEATHER SATELLITES, STIMULATES THE PRIVATE SECTOR'S INVESTMENT IN SPACE TRANSPORTATION. NOAA ALSO ADMINISTERS THE CONTRACT THE GOAL OF WHICH IS

TO PRIVATIZE THE LANDSAT SYSTEM.

- ONE OF THE MOST IMPORTANT QUESTIONS FOR COMMERCIAL SPACE DEVELOPMENT IS THE APPLICATION OF INTELLECTUAL PROPERTY PROTECTIONS. THE PATENT AND TRADEMARK OFFICE HAS BEEN CONSIDERING THE ISSUE IN THE CONTEXT OF THE SPACE STATION.

- ALSO, THE INTERNATIONAL TRADE ADMINISTRATION REPRESENTS A NUMBER OF BUSINESS SECTORS JUST BEGINNING TO CONSIDER SPACE IN THEIR BUSINESS PLANNING, INCLUDING THE EMERGINGING TECHNOLOGIES, ELECTRONICS, AEROSPACE AND MATURE, BASIC INDUSTRIES.

- SERVICES WILL PLAY A MAJOR ROLE IN COMMERCIAL SPACE. INDEED, TWO OF THE MOST DEVELOPED SPACE INDUSTRIES THUS FAR ARE TELECOMMUNICATIONS AND TRANSPORTATION SERVICES. THE INTERNATIONAL TRADE ADMINISTRATION, THROUGH ITS OFFICE OF SERVICE INDUSTRIES, PLANS TO MONITOR THE DEVELOPMENT OF SPACE-RELATED ACTIVITIES TO HELP ENSURE MISTAKES PREVIOUSLY MADE IN THESE INDUSTRIES ON EARTH ARE AVOIDED IN SPACE.

- ANOTHER PROMISE FOR SPACE COMMERCE IS MATERIALS PROCESSING. THE UNIQUE ATTRIBUTES OF THE WEIGHTLESS ENVIRONMENT OF SPACE HAVE ALREADY ATTRACTED THE

INTEREST OF COMPANIES. IN COOPERATION WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, THE NATIONAL BUREAU OF STANDARDS HAS ALREADY USED THAT SPECIAL ENVIRONMENT TO PROCESS "SPACE BEADS", VERY SMALL, NEARLY UNIFORM SPHERES USED TO CALIBRATE MICRO MEASUREMENTS WITH GREATER PRECISION. THE BUREAU WILL CONTINUE TO WORK WITH INDUSTRY TO DEVELOP A VARIETY OF SPACE TECHNOLOGIES.

- ONCE EMERGING TECHNOLOGIES ARE DEVELOPED IN PARTNERSHIP WITH THE PRIVATE SECTOR, THE OFFICE OF ECONOMIC AFFAIRS WILL HELP ENSURE THE SPEEDY TRANSFER OF THIS FEDERALLY FUNDED TECHNOLOGY TO THE PRIVATE SECTOR FOR COMMERCIAL APPLICATION IN SPACE AND ON EARTH.

- FINALLY, THE DEPARTMENT WILL CONTINUE TO SURVEY THE CONCERNS OF ALL SECTORS OF THE BUSINESS COMMUNITY IN THIS NEW ARENA. AS THESE INTERESTS ARE IDENTIFIED, THE OFFICE WILL HELP ENSURE THAT THE GOVERNMENT DOES NOT IMPOSE UNNECESSARY REGULATION OR INAPPROPRIATE RESTRAINTS ON COMMERCIAL DEVELOPMENT OF SPACE. FOR EXAMPLE, IF THE AFFORDABILITY OR AVAILABILITY OF INSURANCE IS AN IMPEDIMENT TO COMMERCIAL SPACE INVESTMENT AS IT CAN BE TO INVESTMENT HERE ON EARTH, WE SHOULD SEEK APPROPRIATE SOLUTIONS. IF ARCHAIC

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ANTITRUST, TAX, OR TRADE LAWS UNNECESSARILY IMPEDE BUSINESS ACTIVITIES IN SPACE, THEY SHOULD BE BROUGHT INTO THE 21ST CENTURY.

OUR RESPONSE TO COMMERCIAL PROBLEMS -- WHETHER THEY STEM FROM EARTHLY CONDUCT OR SPACE-RELATED ACTIVITIES -- SHOULD FOLLOW THE SAME GENERAL RULES THAT HAVE GUIDED THIS COUNTRY'S ECONOMIC DEVELOPMENT. THOSE GENERAL RULES ARE:

- TO WORK TOWARD A STABLE ECONOMIC AND REGULATORY ENVIRONMENT THAT ENCOURAGES, BUT DOES NOT SUBSIDIZE PRIVATE INVESTMENT,

- TO REMOVE ANY GOVERNMENT IMPEDIMENTS TO THE INNOVATIVE AND COMPETITIVE ENERGIES OF AMERICAN BUSINESS, AND

- TO HELP ASSURE THAT THIS NEW MARKET BEGINS AS A FREE AND FAIR ONE.

AS THE CABINET-LEVEL DEPARTMENT RESPONSIBLE FOR LISTENING TO AND REPRESENTING THE NEEDS OF THE BUSINESS COMMUNITY, WE LOOK FORWARD TO THIS EXCITING EFFORT. THE PROPOSED OFFICE OF COMMERCIAL SPACE PROGRAMS WILL FOCUS ALL THE ENERGIES OF THIS DEPARTMENT AND LEAD THE WAY. WE WILL BE HAPPY TO WORK WITH THE SUBCOMMITTEE AND KEEP YOU INFORMED OF OUR PROGRESS.

Mr. NELSON. Okay. Now I want to give you and everybody else in this audience a lecture right now, and I want you to hear me out on this.

It is very important that we expand our—the limits of our thinking and our imagination, and someday space tourism will be a reality. There may be—someday there may be, in fact, hotels in space. But one of the problems that we ran into with the *Challenger* problem was that people started taking space flight too much as if it were an everyday occurrence and a routine matter.

It had become chic to talk about space flight among the upper levels of agencies as routine. Indeed, there were even proposals coming out of some quarters in the attempt at commercialization to go hire an airline to come run the space shuttle launching missions and landings. And the fact is that space flight is anything but routine. Space flight, as we all learned on January of a year ago, is exceptionally risky business, and it's going to be that for a long, long time in the future.

I want to give you this lecture, because it was almost as if, with a cavalier attitude, that you stated what would be the role for the Department of Commerce in the future. And if we let that mindset overtake us, then we're going to have some significant problems as we still are on the cutting edge of going into this extremely hostile environment with very, very complicated machines.

Now I want to ask you, the way you were talking, it sounds like that you're getting the Department of Commerce in a position to be the lead agency on space commercialization. Can you respond to that?

Mr. BRUMLEY. I think by the fact that we have at least three agencies represented here today, Mr. Chairman, that the Department does not seek to be the lead agency on space commercialization.

It has a role to play, and the role is not one that is cavalierly assumed. It is one that has been played and has been played out for a number of years.

We advise Martin Marietta and McDonnell Douglas through our U.S. Industrial Policy Outlook that we issue every year as to the potential of certain markets, such as the telecommunications industry. Our near and long-term projections in the U.S. Industrial Outlook are ones that are not only read here, but are read throughout the country to base investment decisions on.

The Department of Commerce didn't seize that responsibility. It is our responsibility. And that happens to be a medium that is in space, which is a revenue-generating medium.

Mr. NELSON. Who do you think should be the lead agency for space commercialization?

Mr. BRUMLEY. I believe that space commercialization—well, first of all, we have to define our terms.

Space commercialization, as it deals with the offering of technical assistance and the role of Government in stimulating emerging technologies? I think at that point you have a shared responsibility.

Not only does NASA through its Commercial Centers provide that service, but also the President, in his "Quest for Excellence" package, has called for the Federal labs, the National Bureau of

Standards being one of those entities, to have an aggressive outreach program to transfer emerging technologies into the private sector for use.

So I would say that there's not one lead agency in that aspect of it. If it's on transportation, commercial transportation, there is a statutory responsibility for commercial transportation at the Department of Transportation.

There is also a shared responsibility with NASA and quite candidly with the Air Force, because of their relationships of ownership of facilities and also their need to procure launch services.

We also have a responsibility there to look to the private sector to implement the President's policy, if we ever need launch services, and those services don't require the unique requirements of the shuttle.

So if it deals with technical assistance or if it deals with assured access, there is no specific lead, except for the Department of Transportation, through its statutory authority.

All other aspects of space commercialization of private investment in space are going to have to be defined by the activity. If it's telecommunications, we have the lead. If it's materials processing, I don't believe we have commercial activity, as Mr. Gillam has pointed out, that there is such manufacturing going on. If it's on remote sensing, right now Landsat is the only U.S. remote sensing system that is deployed. Therefore, NOAA, in a civil side, not in a commercial side, has the lead. And yet the Department has the lead to transfer that system to the private sector as promptly as it can.

So who has the lead in the commercial use of space, as who has the lead in private investment in, say, the Pacific Rim or in Europe? No one has the lead.

What it is, is we all need to pull together with a clear policy direction of making space a stable investment climate. That is neither cavalier, nor is that unique. We have done it since the turn of the century, and we think space is the next logical step to extend our concerns.

Mr. NELSON. The Act says that NASA is to foster to the maximum extent feasible the commercial use of space. The implication there, the legislative intent is that the lead comes from them. If we have to clarify that, we will clarify that.

Now, let me ask you about—are you the Chairman of the Commercial Space Working Group?

Mr. BRUMLEY. Yes, sir. Let me amend that. Actually, the Secretary is the Chairman, as established under NSDD–144, I'm his designate. I serve at his pleasure.

Mr. NELSON. Okay. And what is its charter?

Mr. BRUMLEY. Its charter is to identify Government imposed impediments to commercial space investment and at the same time, to foster private investment in space.

Mr. NELSON. And before you said "to foster private investment in space," you said that?

Mr. BRUMLEY. Identify Government imposed barriers or impediments to the commercial use in space.

Mr. NELSON. All right, and who are its members?

Mr. BRUMLEY. The members are the same members of the Economic Policy Council. It would be those organizations such as the

Department of the Treasury, USTR, NASA is the Vice Chair, Department of Transportation, OMB.

Mr. NELSON. All right. Did you all get involved on the question of the replacement orbiter?

Mr. BRUMLEY. On that specific question or on a collateral issue?

Mr. NELSON. On both.

Mr. BRUMLEY. We did not get involved in the question of the replacement orbiter. We got involved in an issue as to commercializing ELV's. That was one of the issues that had to be resolved before the question of the replacement orbiter could be addressed. As it was discussed here, when Mr. Gillam testified, until you understand the use of your capacity and the demand on the three remaining orbiters, that demand being potentially a demand that could be handled by Air Force procurement or commercial ELV's servicing that manifest, you don't really know if you need a replacement orbiter, and so until those issues were resolved, you could not get to the decision of whether or not you buy a fourth orbiter, so one of the issues, one of the collateral issues underlying that decision was commercializing expendable launch vehicles.

Mr. NELSON. And you said that before you could get to the issue and decide whether or not you needed a replacement orbiter, you had to answer the question whether or not you needed to commercialize ELV's?

Mr. BRUMLEY. You needed to answer the question of what was the demand in terms of the three remaining orbiters. If commercializing ELV's would alleviate the demand, then it would go to the question of how much capacity do we need in terms of orbiters, so if commercial ELV's would take some of the payloads off the manifest and therefore take the pressure to launch off the manifest and if some, such as the Air Force procurement would take other payloads off the manifest, and other actions would further reduce the size of the manifest, then you were left with what is the true manifest, and then you look at the number of vehicles you have, their unique capabilities of carrying that cargo and that leads you to the conclusion that you either have less than enough capacity or you have excess capacity.

As it turned out, the President's decision led to the conclusion in fact that we had less than enough capacity to handle it and we needed a fourth orbiter. I think Ike in running his numbers indicated today also that there may be a requirement for a fifth orbiter, but that is a demand function.

Mr. NELSON. You came to a conclusion, did you not, that you did not want to have the commercial payloads on the space shuttle and therefore you wanted to commercialize the ELV's which had been a decision that the President had made several years before?

Mr. BRUMLEY. Just the reverse, sir. You are right. The President made the decision as a statement of policy that he wanted to foster and encourage the development of a commercial U.S. expendable launch vehicle industry. Because of that policy and because of the review in terms of the requirements of providing launch services for American payloads that were on that manifest, it was an opportunity to accelerate that policy to the point of actually commercializing expendable launch vehicles.

The number of payloads didn't drive the commercialization. The policy was already there. What it did, however, it complemented the decision to buy a fourth orbiter because it took the pressure off the remaining three and the fourth orbiter as it comes down the line to deal with commercial revenue generating cargo, which is not in terms of a national resource, like a space shuttle, something that it should be carrying, in competition with the private sector.

Mr. NELSON. You were aware that even by taking those commercial payloads off of the space shuttle, that there were going to still be more payloads than three orbiters could ever launch and therefore you had to have a fourth orbiter?

Mr. BRUMLEY. The decision was to buy a fourth orbiter. I don't know what the final numbers, when you factor in commercializing payloads——

Mr. NELSON. Okay, I know the decision was that. Earlier you said, about 2 minutes ago, that you had to answer the question whether or not you were going to commercialize ELV's before you get to the question of whether or not a fourth orbiter was needed.

Mr. BRUMLEY. Yes, sir.

Mr. NELSON. Okay. I'm saying that you understood in the process that even with commercializing ELV's, there were far more payloads that needed to be launched into space than three orbiters could accommodate.

Mr. BRUMLEY. No; that's not what I'm saying. What I'm saying is that at least for commercial payloads that did not require the unique characteristics of the shuttle or that were not foreign policy payloads or national security payloads, which were the three exceptions the President announced, except for those three categories, we could move some of the pressure on the manifest into the private sector.

Now, how many of those payloads in comparison are in addition to how many defense payloads were also moved off and how many science payloads may be moved off the shuttle to commercial ELV services, I don't know. All I know is that in terms of those 44 payloads, the group focused on that to determine whether or not commercializing ELV's would help not only create this new industry but at the same time, service that manifest.

Mr. NELSON. Well, earlier in your testimony, I want to make sure that we are hearing you correctly, and if we are not, I want you to correct me, and if we need to, we will have it reread from the record as to what you said, I am under the impression that you said that the reason for this Commercial Space Working Group, of which you chair, on the issue of the replacement orbiter, was in fact that you needed to determine in order to determine if we were going to need a replacement orbiter, first, if we needed and if we were going to commercialize ELV's.

Is that not what you said?

Mr. BRUMLEY. No. Again, what I said was that the issue of the replacement orbiter, there was a collateral issue. There were a number of collateral issues. One of the collateral issues was commercializing ELV's and the pressure by commercializing ELV's, the relief of pressure on the manifest by moving payloads off onto those ELV's; now, if at the end of the process, the requirements

would be still for a fourth orbiter, than that would require the decision to buy a fourth orbiter.

Now, whether or not it was based on purely the total number of payloads on the manifest or also based on the requirement, as Dr. Fletcher has testified, that you need a fourth orbiter over and above demand but also for insurance because we may lose another one, those were factors that were also considered.

But the commercial ELV decision was not the driving decision to buy a fourth orbiter, and that may be what you misunderstood me to say. It was not the decision. It was one of a number of decisions that had to be made before that final decision could be made.

Mr. NELSON. Well, it was certainly the driving decision, was it not, in the deliberations of last year, that held up the decision——

Mr. BRUMLEY. Absolutely not.

Mr. NELSON. How many months did it take you to come to your conclusion?

Mr. BRUMLEY. Two weeks.

Mr. NELSON. All right, and from what to what was that period of time?

Mr. BRUMLEY. We first met July 15. We had the EPC meeting July 30. The President made the decision on August 15.

Mr. NELSON. What was it that held up your deliberations until July?

Mr. BRUMLEY. The process in SIG Space, and it wasn't held up. It was there where a lot of other integral decisions that had to be made. Ours was just one. I believe right after the fourth of July weekend is when we got the assignment.

Mr. NELSON. Did this Commercial Space Working Group sit in and participate with SIG Space?

Mr. BRUMLEY. No, sir.

Mr. NELSON. So it was a totally separate deliberation?

Mr. BRUMLEY. Yes, sir, but you have to understand that membership in the Commercial Space Working Group either at the principal or the staff level, may also be the same membership on the SIG Space. In other words, it may be the same individual who sits at that SIG or the IG Space level.

Mr. NELSON. Was it in fact the same?

Mr. BRUMLEY. In some cases, yes; in some, no.

Mr. NELSON. With SIG Space? Did you sit on SIG Space?

Mr. BRUMLEY. No, sir. Deputy Secretary Brown.

Mr. NELSON. In other words, the Department of Commerce did sit in on SIG Space?

Mr. BRUMLEY. Yes, sir.

Mr. NELSON. And they were considering all of the questions otherwise, other than commercial ELV's as to whether or not there was a need for a replacement orbiter?

Mr. BRUMLEY. Yes, sir, of which the commercial ELV's was one.

Mr. NELSON. And why did that take SIG Space from January, the end of January until August to get a recommendation to the President?

Mr. BRUMLEY. Well, first of all, the SIG Space only met on the issue one time and that was, as I understand it, and correct me if I am wrong, Ike or Courtney, in May sometime. I take that back. It was in April. It was in April they met and then they had their

presentation at the National Security Council in May. So it would be approximately from January 28 and actually a few days after that for the staffing action at the IG Space, which is the second level body, the staff level body of SIG Space, that worked it from February until April.

Mr. NELSON. I was deterred here. Would you state that again?

Mr. BRUMLEY. Sure. After the accident, giving a leadtime for a few days for response in terms of staffing and decisions to establish the Rogers Commission and a few other decisions, I guess within about a week, it was decided that the IG Space, which is a working group, which is a subgroup of SIG Space, would meet and would develop a working group to make a recommendation on procuring a fourth orbiter.

It took from that time in February until April to report its findings to SIG Space. SIG Space in turn put together the paper and presented it to the NSC in May and then at that point in May, the decisions that remained to be answered were then addressed; the budgetary issue with OMB, just as the space station issue is being discussed with them now. They had to address that. The commercial ELV issue had to be addressed and was assigned, by the way, at Dr. Graham's request, to the Economic Policy Council.

So the EPC then staffed it out in July.

Mr. NELSON. Who are the members and/or the designees of the Commercial Space Working Group?

Mr. BRUMLEY. I don't have all—I'd be glad to provide that.

Mr. NELSON. Okay. If you would provide that for us, we would appreciate it.

[Witness indicated they could not provide material.]

Mr. NELSON. Did the President accept all of the recommendations of the Commercial Space Working Group?

Mr. BRUMLEY. I cannot say. I don't know. I wasn't at the meetings so I can't—all I know—I was on my 2 weeks military duty at the time he made the decision.

Mr. NELSON. Who was at the meeting from your Department?

Mr. BRUMLEY. Cabinet Secretaries only; Secretary Baldrige.

Mr. NELSON. All right. Would you provide that?

Mr. BRUMLEY. Certainly.

Mr. NELSON. We would like to know what were the recommendations and what were the recommendations they accepted and the recommendations they did not accept.

Mr. BRUMLEY. With the understanding that I will contact Cabinet Affairs to make sure I can release that information. I'm not sure if I can.

Mr. NELSON. Well, if you can't, we can find somebody who can.

Mr. BRUMLEY. Yes, sir.

Mr. NELSON. I would appreciate the start of that.

Mr. BRUMLEY. Taking a good lesson learned, when I first came in here, you said, don't try to answer any questions that should be left to the Administrator or vice versa. I'm just saying, I can't answer that question.

[Witness indicated they could not provide material.]

Mr. NELSON. Can you answer this question; were there any elements of the President's decision that were not part of your recommendations?

Mr. BRUMLEY. Dealing with a double negative there. Were there any elements of our recommendations that was not part of the President's decision? The final paper that supported the decision encapsulated everything that we discussed, whether explicitly or implicitly, so I would have to say that the President's decision encompassed all of the efforts of the Working Group.

Now, I defer to Ike. Ike is Vice Chair. Do you feel the same way?

Mr. GILLAM. Essentially, that's correct. There were a few details and a few minor elements that were not incorporated into the final decision, if my recollection is correct, such as minor recommendations for working groups and that kind of thing for implementation.

Mr. NELSON. The question further is were there any things in the President's decision that were not in your recommendations?

Mr. GILLAM. Oh, the answer to that is no.

Mr. BRUMLEY. No.

Mr. NELSON. In other words, everything that you recommended—no, not that.

Mr. GILLAM. There was nothing new in the decision that was not a part of the recommendations.

Mr. NELSON. Let's talk about this—when does the Department of Commerce intend to try to establish an Office of Commercial Space Program?

Mr. BRUMLEY. When, quite candidly, we find a qualified Director and when we do, and we are interviewing now, we will establish the office around that Director.

Mr. NELSON. And when would we expect to see proposed legislation for this office?

Mr. BRUMLEY. The office right now is in the Office of the Secretary, reporting to the Deputy Secretary and it is a clearinghouse of information, with no statutory function except for providing—consolidating and providing information to the private sector. It is a consolidated place to go to get information that may be difficult to get in an organization as large as ours, but it is not assuming any kind of program role.

Mr. NELSON. Well, how many staff are going to be assigned to this office?

Mr. BRUMLEY. Two; a policy analyst and a clerical.

Mr. NELSON. We have been through this office within the Secretary's Office before. You can ask Mr. Stadd about the history of that.

Under what authority is this program to be established?

Mr. BRUMLEY. It will be funded out of the discretionary funds of the Secretary, the Office of the Secretary, but in terms of authority, it's very basic to the Department, and that is—I believe it is chiseled on 15th Street at the Secretary's entrance and that's to stimulate domestic and international commerce. We feel that space is the next business sector, one of our responsibilities is to do that and it is a statutory responsibility. Space has unique characteristics but its problems are just like problems here on earth in a number of areas so we are focusing our attentions on this particular sector until such time as that particular business sector stabilizes.

Mr. NELSON. Well, in the way that you drew in your opening comments the idea of a hotel in space——

Mr. BRUMLEY. I wish that was my idea. It wasn't.

Mr. NELSON. You had some pretty grand designs for this Office of Commercial Space programs, even to the point that you were going to bring in the U.S. tourism—U.S. TTA, U.S. Travel and Tourism Administration, you were going to bring them into the act, which were your words.

Mr. BRUMLEY. Well, they are our organization. They are within the Department of Commerce.

Mr. NELSON. Well, I understand that, but I mean, suddenly you are talking about an Office of Commercial Space Programs within the discretionary funds of the Secretary and now you are bringing in the U.S. TTA for some future hotel in space.

Mr. BRUMLEY. Well, if Congressman Walker's hotel ever gets deployed, I will tell you that the U.S. Travel and Tourism would be very, very happy to try and stimulate as many people to venture up there as possible, assuming transportation is available.

Mr. NELSON. You see, that may not be the place though that you want to be encouraging, space tourism.

Mr. BRUMLEY. But the point is, Mr. Chairman, that the Department has 35,000 employees. This office is not going to pool together any staff in an office to be an entity unto itself. What it is going to do is through the management of the Office of the Secretary, dealing directly with the programs that are affected, ask the career professionals who are in those programs, who will remain in those programs, to give us either advice or be able to be available for private sector inquiries as to space as a business sector.

So, as an example, and this is a real example, it is a program that NASA is aware of, it is called the Phoenix project, it has been around for a while, the use of the external tanks as sort of a butler building in space, external capacity, they want to know—they come by the Department of Commerce not to know about its technical capability or whether or not the launch system is one that can be supported by ELV's, they want to know in terms of risk management, is there sufficient capacity out there to ensure either through the risk retention act or through other mechanisms, private mechanisms, to provide sufficient insurance capacity to underwrite the project.

The risk retention act, we can then advise, has been amended by the actions of this Congress, the 99th Congress, to allow pooling for certain forms of risks, in particular, casualty, which will bring enormous amounts of capital to bear to allow projects like this to go forward, whether it be a butler building in space or it be a baby seat manufacturer in Toledo.

I mean, the point being is that the applicability of risk management is nonsectoral. The Department is not going to pull any career professionals into the Office of the Secretary to give that advice. It is just—that office is just going to be a clearinghouse. You come to the Director. The Director says, you have an insurance problem and he is there to talk about it. Well, I suggest you go see so and so in the Department and he in fact works as a facilitator to make sure that the taxpayers' money is getting the biggest

bang for the buck that they can get in terms of technical advice in that particular area.

So that's all the Department is doing. It has done it in the past. What we are trying to do now is rationalize and focus a function, because now people who come into the Department who may have an interest in doing business in space may go to the International Trade Administration but not realize that they should also be at NTIA, the National Telecommunications and Information Administration, or they may go to NOAA and not go to NBS or they may go to NBS and not go ultimately some day to Travel and Tourism.

Mr. NELSON. Well, let me tell you something that, you know, as we look to the future, each of these agencies has a role in coming forth and utilizing their specialty, and that ought to be encouraged. But when major decisions about the future of this country's space program are being decided in a yes-or-no situation, as was last year the case with the replacement Orbiter, and is being decided by people who don't understand anything about space, and who grind the wheels almost to a stop by the decisionmaking standpoint—I'm not saying you are that, I'm just telling you what is the perception up here on the Hill of what happened into almost a disastrous policy of almost killing the replacement Orbiter.

We have seen the same kind of thing start to be replicated this year on the question of the Space Station. A decisionmaking apparatus that has been unable to make a decision because there are so many cooks in the kitchen who don't know anything about how to cook the stew. And I can tell you that the responsibility of the Congress up here, and the ones who appropriate the money and then have the oversight of the executive agencies, is that we are not going to let that situation occur again. We came that close to losing the replacement Orbiter. Anybody who understands anything about space understands that it's inevitable that you have to have a replacement for *Challenger,* regardless of what your commercial policy is on commercial satellites, and what's going to be launched, simply because of the demand of having assured access to space. And yet the system ground and ground and ground and was slowed and took from January 18 all the way up into October, into September, before it could ever get a decision to proceed. And that is just not a tolerable decisionmaking process in what the people of this country expect in the way that they should have a space program.

So when we look at this commercial space working group, and we see that you chair it, and you don't have any expertise in space, and yet you are the chairman of this—I'm not talking about you personally, I'm talking about you as an institution—then we have to wonder what in the world is going on in this Administration. When you start talking about setting up an Office of Commercial Space Programs, and you start saying, well, we're going to do this out of the discretionary funds of the Secretary, and we're going to do this under the authority of that—I hate to have to get into the thing that we've gone through with the Department of Transportation, but, you know, we've been through that once before, and that's just simply not going to happen.

Mr. BRUMLEY. Mr. Chairman, two points. One is that I agree with you, the American people needed a decision, but I think we

both can agree they needed an informed decision, and an informed decision was one that was waiting for a number of things to happen, particularly the Rogers Commission Report. To step up—and this is my own personal view, not the views of the Department—but to step up and ask the President of the United States to make a decision on January the 29th about buying a replacement Orbiter, without first finding out what went wrong and why, and how can we best recover in terms of what went wrong and how, and how we can best use the very limited resources that we all know we don't have in terms of budget, as well as resources within agencies, until all those decisions are made, he doesn't have—he doesn't have a decision to make. He's merely being asked to ratify someone's narrow view about what is best for them.

The President got an opportunity to make an informed decision, and he made it in August. He made the appropriate one.

Mr. NELSON. Now you can't make a justifiable argument on what you just said, because the Rogers Commission reported in the first week of June.

Mr. BRUMLEY. That's true, sir.

Mr. NELSON. It was late September before the President ever got around to finally coming forth with the Orbiter.

Mr. BRUMLEY. No, sir, it was August 15.

Mr. NELSON. Ah! It was August 15 when the President came out and said, "We finally need a replacement Orbiter," but he never did provide the funds, he never did point to a way in which it could be funded. It was left up to the Congress.

Mr. BRUMLEY. The Rogers Commission again was one portion of the decisionmaking process that had to get out of the way before—

Mr. NELSON. And that was early June. That was early June.

Mr. BRUMLEY. Oh, absolutely. But then again, as I've told you, the July program that we had on commercial ELV's had to be taken out of the way before he could make an informed decision. Decisionmaking like that is not done sort of like four abreast. It's done integrally, so that at least you can deal with those issues and focus your attention on them, and once it is done, once it's concluded, it leads you to the conclusion of yes or no, we're going to buy or we're not going to buy. I believe again, personally, that his decision on August 15 was not premature and was not late. It was at the right time.

Mr. NELSON. Well, let me tell you, rather than you get into a defensive posture, I can tell you that fortunately there are some folks down there who now know what's going on. One of them is Mr. Carlucci, and the skills of Senator Baker now as the Chief of Staff are such that I think we are going to see a more forthcoming decisionmaking process with regard to the space program.

So I wouldn't get yourself in a posture where you become the defense advocate for what happened in the process last year, because a decisionmaking process like that is inexcusable and indefensible. And I'm not talking about you personally, I'm talking about the whole system. People who care about this space program and people who happen to know something about it—not necessarily here on this committee, but in other parts of the Government, in

fact, were just appalled at that kind of decisionmaking apparatus that would grind everything so slowly.

Let me shift gears here. Just yesterday the Appropriations Committee finally, very fortunately, passed language in a supplemental appropriations bill for $62.5 million to go ahead with the Landsat. There was a caveat put on that that had the second satellite of a two-spacecraft system was going to have to have funds coming from other users other than NOAA. So how can you comply with that language that will allow you to secure funding from users of Landsat to pay for the second satellite?

Mr. BRUMLEY. I can't respond to it. Number one, I don't know about the appropriations decision yesterday; but number two, that's a decision of the Secretary in consultation with Under Secretary Calio of NOAA, and if it leads them to discussions interagency, I'm sure that they will have them.

Mr. NELSON. We will get Dr. Calio here and talk to him about that.

Okay. Chris, I took a long time.

Mr. PERKINS. That's fine, Mr. Chairman. I was enjoying it, as a matter of fact. I'm not going to be very long with you, Mr. Brumley. I do have some things that concern me. I think the thrust of what the chairman was talking about is we want commercial process both in government and out of government that drives the advancement towards space, as opposed to in any fashion hindering that process. And, you know, one of the National Commission on Space's reports was talking about something that we have been discussing, the Eosat-Landsat situation, and I'm just wondering—you know, remote sensing is being increasingly competitive area. What types—I'm going to ask you this same question in terms of a number of areas, a number of which are addressed in your formal statement, but I'm just interested in terms of the Department of Commerce's position as to how they are maintaining us on the leading technological edge in competition with the variety of other countries in the world that today we are in competition with, with areas such as remote sensing and, of course, I guess the Department of Commerce did have the role in trying to develop the Eosat Program, but today you haven't really seen development per se.

Could you just tell us a little bit about how we are staying competitive in remote sensing?

Mr. BRUMLEY. Well, in terms of staying competitive, we are—that would imply a private-to-private competition, which there isn't right now.

Mr. PERKINS. That's right.

Mr. BRUMLEY. We would hope that there would be a U.S. private——

Mr. PERKINS. Well, let's just talk about maintaining the technological edge. Let's not talk about, you know, in terms of a privatization competition at the moment. That doesn't exist. But the technology is being developed in Japan, in Europe, that is going to place in a very relatively short amount of time, remote sensing with our Landsat operation. And of course, Landsat has been one of the areas that a lot of governments around the world have been interested in for years. What are we doing to push that technology? What is Commerce doing to push that technology?

Mr. BRUMLEY. Well, what I understand—and I am not a Landsat expert or really an expert in remote sensing—what I understand is that at least in the area of—where commercial activity is occurring right now, photo imaging, satellites, and remote sensing itself, the genesis of our technology came from Government-funded research, and that government-funded research, whether it be in a national security sense or in some other transformation after national security development of particular technology, led to someone considering it having civil application, and then finally, ultimately, commercial application.

I am told—and I don't know if this is accurate or not—in terms of photoimaging, for example, the advancements are not exhaustive, but the advancements available in civil—for civil and commercial purposes have pretty much reached the limits that they can reach, and that's one of the reasons why Spotimage can—they can develop a system and put it up there and make it commercially viable, because the technology is really mature technology in that area. And we are talking about mature technology in some of these areas, that is like—mature is 2 or 3 years ago, as opposed to mature in some of the more basic industries that we have.

Who is feeding further and further heightened remote imaging or photoimaging technology into civil application and commercial applications, I would think would be that organization that has a need for heightened photoimaging and heightened remote sensing capability, which would be in the national security arena.

Do we in fact transfer the data? No. We are kept abreast of the—NOAA is kept abreast of the advancements in the field, it participates in the advancements in the field, to the degree that it is allowed to participate, and does so in terms of its program needs.

I would be very surprised if NASA doesn't have such an office or a code at their organization where they also participate in this leading form of technology. But where it stands now, at least in terms of what Spotimage does, it's no longer a question of being able to take a certain type of a photograph, it's a question of the resolution of the photograph, the interpretation of the photograph, and the quality of the photograph in commercial terms.

So I'd say that the history of how it got there today is probably an example of 3 or 4 years from now the next step, the next generation of those kinds of systems, and where they will come from, as well.

Mr. PERKINS. Well, Eosat hasn't worked at all. And of course, as a partner, the government hasn't been a great partner to private industry. But this is a fundamental problem with space commercialization, venture capital, the amount of venture capital necessary to buy into the process such that it's frankly a barrier, along with the risk factor, of having very many firms that are interested at this time in engaging.

Mr. BRUMLEY. Venture capital obviously is one of the first—well, capitalization is one of the first concerns after concept of product, whatever the product is going to be. But in the area of these systems, they are in the value area, based on the revenue return that they can receive over time.

In other words, the profit motive is sufficient out there, as it was in telecommunications five or six years ago, and it is now, that it offsets that near-term high capital requirement.

Mr. PERKINS. Then why hasn't Eosat worked?

Mr. BRUMLEY. Eosat is the privatization of an existing Government system, okay, and that is different than the private sector deciding to develop, like Spotimage, their own system. Now, again, the French model is not truly private, but they use that as a——

Mr. PERKINS. It's government subsidized.

Mr. BRUMLEY. But if you have a truly private photoimaging system, that to me is different than what the Government is trying to do. They are trying to take and privatize an existing Government system and transfer it into the private sector.

Mr. PERKINS. What are the problems with it presently?

Mr. BRUMLEY. Oh, I think the problems would be the same as with the shuttle. If you were trying to privatize the shuttle, you would have the same concerns of not just the cost of transferring it to a willing buyer of the system, but also assurances that that willing buyer will use the system, use it in such a way that there is general benefit to all, as opposed to exclusive franchises or monopolies or something to that degree. So, in other words, that the market has an opportunity to play in it.

Mr. PERKINS. How many willing buyers do you have that are interested in becoming involved in Eosat? I think there were a couple a few years ago, just from what I read somewhere in some report.

Mr. BRUMLEY. I really don't know. I know that as far as the problem itself is concerned, it's—it is a question of what is the best form of the system to make it commercially attractive with a lifetime of a revenue stream to attract a willing buyer.

Mr. PERKINS. How is Commerce trying to do that, since they're the lead agency in this?

Mr. BRUMLEY. Working with Eosat, and Eosat agreed to the original proposal, the original contract that they entered into, but we have run up against, which you are well aware, and the appropriations issue dealt with, and that's whether or not there's a follow-on system and at what cost. If there is not a follow-on system, whether it be a follow-on Landsat system or a follow-on anything, if there is not something that can extend that revenue stream, then in a private sector sense it may not be commercially attractive to a private company. And I don't know about Eosat—what is going through Eosat's mind, but I would think in dealing with the Government they want to get the best deal that they can get. We in turn want to be able to privatize the system as a policy goal, and as a secondary goal, we want to make sure that that system is used to the benefit of the United States.

So I—but the particulars of Eosat's problems, I'm not aware.

Mr. PERKINS. All right. Material processing—I mean it seems like a major field. Where are we?

Mr. BRUMLEY. Mr. Gillam gave a good report about the status of materials processing——

Mr. PERKINS. I read that.

Mr. BRUMLEY. The space needs are, at least from our experience, were the most—are one of the most tangible returns in dealing with materials processing. It's an industry that has to be depend-

ent on not just what you're going to process, what materials you're processing, but at the same time it deals with the environmental concerns of long duration, manufacturing, access to space, market demand, is there a demand out there for the space needs, a commercial—a sufficiently high commercial demand that a private company with private venture capital would be willing to develop a private system and deploy it through private transportation means in space on either the Space Station or free flyer to manufacture certain materials, or process certain materials? Now I don't think the industry has matured to that.

Mr. PERKINS. Mr. Brumley, I guess I am not getting a real good grasp of what role the Department of Commerce is playing in this.

Mr. BRUMLEY. In terms of what, materials processing?

Mr. PERKINS. Yes. In terms of material processing, remote sensing—I mean remote sensing, you tell me Eosat is the private corporation. Materials processing, we point to the other report on the space beads. What is Commerce doing?

Mr. BRUMLEY. First of all, you have to work backward from what is space right now. Is space a business sector? Is it a place where people can make money? If it's not, then we have no role in it. If it is, commercial communications satellites are generating revenue streams as we speak right now up there. That's number one.

Number two, is whether or not we own the system, there is someone making money, private money, in photoimaging through either Spotimage, or hopefully, ultimately, a U.S. private satellite, that type of a system.

Mr. PERKINS. Well, it strikes me that the Commerce Department should be trying to take an active role in promoting the technological advancement. And I'm waiting, I guess, for my own ears to hear some sort of policy or program that the Department of Commerce is attempting to formulate or utilize that would ensure some sort of advancement or driving, as I said in my initial statement, as opposed to just being some sort of responsive agency.

Mr. BRUMLEY. Well, we take our responsive role very seriously, but you are absolutely right. In terms of moving the technical expertise to the private sector, the Department has been in the forefront in a little office within the Office of Economic Affairs, called OPTI, the Office of Productivity, Technology and Innovation, which has pushed for 5 to 6 years for a patent policy that leads to Government relinquishing patent rights to contractors who do Government or federally funded research, so that they have at least some control in a patent sense over the fruits of that joint venture.

Number two, the Department has been pushing as of late with the support also, quite candidly, of organizations like NASA, to make sure that the additional aspects of that proprietary technology—meaning the copyrights, the technical, the trademark rights, and the rights to the technical data are reposed in someone who will use it for some commercial activity.

Now that office has been pushing that for a number of years and has had a great deal of success. Ike's office and his success of his commercial centers is an example of an organization that has taken advantage of that policy and is in fact in the work that they're doing through these centers, getting the private sector in-

volved in a technical sense in developing certain kinds of emerging technologies.

The National Bureau of Standards does the same thing. Federal labs, Oak Ridge, the ones in Denver, the same thing. They are all being coordinated, not necessarily through the Department of Commerce, but they are all being coordinated through an oversight mechanism within the Administration, or a policy mechanism, I should say, within the Administration that seeks to transfer this kind of federally funded research into the private sector for commercial application.

Now Commerce is involved in that. We are involved in it without regard to space as a sector. We are involved in it in any business sector. But where you get to the next step, we have one organization pursuing that technology whether it be with a grant university to develop. We have another organization within the Department that's concerned that when that university sees commercial application in whatever this federally funded research was, it will go out and find a private contractor, an entrepreneur, usually, to commercially apply that research. And when it goes and does that, we're finding out some of these universities have a product liability exposure. And as a result they are reluctant to go out and find that commercial contractor, that commercial entrepreneur.

Now you take it from that point backward, risk management, insurance, product liability, back to the tech-share program, if you can't find a willing partner to transfer the technology that you have mutually developed into the private sector, you have lost the competitive edge. And I think that's represented in the President's Quest for Excellence package, because he's noticed in the Science & Tech recommendations, we have a long way still to go, and he's hoping to issue an Executive Order pushing us further down the road of tech share.

Mr. NELSON. Would the gentleman from Kentucky yield?

Mr. PERKINS. I'd be pleased to.

Mr. NELSON. I'm going to ask you a business question, Mr. Brumley, not a space question.

Mr. BRUMLEY. Thank you.

Mr. NELSON. Did the government, et cetera, the Department of Commerce, enter into a contract with Eosat to make private the Landsat system?

Mr. BRUMLEY. I know there's a contract. I don't know who the parties are. I assume it would be the government and I assume it would be Eosat, but I have never seen the contract. I'll be glad to provide the information to you.

Mr. NELSON. Well, the answer to that question is yes.

Now you may not be, then, by your response to that, you may not be the person to ask.

Mr. BRUMLEY. No, it would be Dr. Calio, sir.

Mr. NELSON. All right, we will. Well, I'll just tell you what the truth is, then, as long as you're here.

Mr. BRUMLEY. Would you like me to carry this back to Dr. Calio?

Mr. NELSON. You may well, and he can be prepared for when he comes up here.

And this is a business question, it's not a space question, and that is, did the U.S. Government enter into a contractual arrange-

ment with a new private entity called Eosat, which was made up of a bunch of aerospace companies, that were going to provide some Landsat satellites, and we were going to sell the data, and it was going to be the great new enterprise?

And there were things that the Government, under this contract, was supposed to provide; namely, up-front money. And the fact is that that hasn't been met by the Government, because of foot dragging of the Department of Commerce and NOAA. And thanks to the Appropriations Committee, just yesterday they finally come up with this thing that's going to save the Landsat system, which by the way is extremely important to the national defense of this country, and there is another example, because we're getting so many cooks in the kitchen who don't understand something about space, we're about to lose a major system that is important to the defense of this country.

Now Mr. Calio knows something about space. But he has been muzzled in the process, and he has not been able to be forthcoming and got mish-mashed around and the Government didn't live up to its obligation under the contract. You take that message back to him and to Mr. Brown, and to Secretary Aldridge.

Mr. BRUMLEY. Understood.

Mr. NELSON. And we will visit with them. Certainly you as an attorney could not recommend to a client that they would enter into an agreement with the U.S. Government if you knew that the experience was going to be one for your private client that the private clients have had in the Eosat experience.

Mr. BRUMLEY. No comment on Eosat, but as far as I am concerned, I would like to see private clients deal with private clients, and not deal with Government, because we are always a lousy business partner.

Mr. NELSON. Now you see, there's the difference. In this case the private enterprise had to deal with the Government, because it was a Government system. And it's an extremely expensive system. And, in fact, the Government did realize that fact, and therefore it entered into this contract that said that the Government was going to put in the up-front money to keep the LANDSAT system going, because the Government had a stake in doing that. And then it got shuffled around and shuffled around, and decisions were made by indecision, and right at the last minute, assuming this amendment to the 1987 appropriations, supplemental appropriations bill that was passed yesterday, assuming that that ultimately passes, finally at the last minute it's going to be pulled out of the fire.

But, you know, why do we have to make decisions this way? Why do we have to get into America's space program—us sitting up here, and being schoolmarms, trying to oversee and discipline a bunch of agencies that are in a turf battle trying to get into the business of space because it's a sexy subject.

You know, it shouldn't have to be that way, but in fact over the last several years, it has. Now if we had to do this thing all over again, I don't know how we'd do it, but we surely wouldn't have done it the way that it has been done.

Well, I've pontificated enough. But I hadn't—this isn't the last.

Mr. Perkins, do you have anything more?

Mr. PERKINS. I would just like to ask one other question, I think, and that is in regard to the Space Station. With the Space Station, we are having a little problem that we were having, as the chairman said earlier, with the—I guess the Orbiter last year, end of the month is coming, we need some information, what role is Commerce playing in that?

Mr. BRUMLEY. On the Space Station issue?

Mr. PERKINS. Yes.

Mr. BRUMLEY. Well, Commerce is part of the negotiating team, along with the State Department, which is lead, and NASA, and the Department of Defense. Other than that, Commerce's participation in the Station has been consistent with that. Do you mean the budget issue?

Mr. PERKINS. Yes.

Mr. BRUMLEY. That's held with the people who do the budget.

Mr. PERKINS. When did you put your info or your input into that process on the budget, out of curiosity?

Mr. BRUMLEY. I don't know if we—I don't know if we have ever inputted on the budget issue. We have never been asked our comment on the budget issue, that I'm aware of.

Mr. PERKINS. Okay. So, in other words——

Mr. BRUMLEY. I'm speaking for the Department. I don't know if some other element of the Department may have submitted something. I doubt seriously if it has.

Mr. PERKINS. Okay. So you're not one of the ones who's had input to OMB on this?

Mr. BRUMLEY. I don't think the—again, I may be—this is my own personal view—I don't have a sense that there has been a solicitation of policy input or dollar input on the Space Station from OMB at Commerce. And I don't know about any of the other agencies, but we certainly haven't. Now there was an original decision made back in 1982 or 1983, that wasn't a budget decision, that was a decision to have a Space Station.

Mr. PERKINS. All right. Again, in the same framework as before, if you can just talk about what Commerce is doing on the competitiveness issue in regards to the space station.

Mr. BRUMLEY. Well, in particular, the Space Station, if it's going to be—if it's going to have a commercial capacity and be a commercial platform, at least one of its goals would be to be a commercial platform as Mr. Gillam has testified.

We want to make sure that two things occur. Number one, that the mistakes of the past in terms of, as the Chairman has pointed out, taking space too lightly as a form of reliable or safe environment in terms of either transportation, manufacturing, is pointed out to those who are going to be encouraged to use that platform for commercial purposes.

And number two is that the use of the Station is not antagonistic to the development of follow-on private sector free flyers and, as Mr. Gillam has testified, they factored that into their concern, that free flyers will be attracted to group around the station. Max Faget's facility, they are making plans on having that system actually coupled with the Station. So we just want to make sure that the Station, if it has a commercial role, is a role that doesn't prove to be a barrier, but in fact one that fosters activities.

An example of a barrier would be a very—a singular facility called the Space Station in which you do materials processing if you have a market for that business sector or that line of commerce, and yet you can't afford to pay energy costs or else the facility is not built so that it can accommodate what you have to do in it. You have to design your systems to be—to operate within it, as opposed to the system is designed to be sufficiently elastic where you can put your systems in it, make a cost-effective manufacturing process, and get out.

It's that kind of a concern that we would have, to make sure that the commercialization of an element of the Space Station is not actually a barrier, does not actually divert the market away from more cost-effective, simpler systems. And beyond that, there are concerns about what's made in the Station, how the application of the trade laws will be applied within the Station.

We have, or we hope to have, an arrangement with our trading partners to not only manufacture or conduct research and development in the Station. How are we going to make sure that our concerns on technology transfer are taken care of, but at the same time not at the expense of American firms?

Our allies, our trading partners, have shown us very clearly that they see an enormous commercial potential in Space Station oriented technology. They have created an organization called Novespace in France. It's 48 percent owned by Cnes, and then an amalgamation of French banks, and in their glossy prospectus, they talk about one of the goals of Novespace, which is to take space oriented technology and transfer it into nonspace business sectors, ostensibly to compete against our own products either in Europe or here in the United States.

We need to be that forthcoming. We need to have mechanisms that are that focused in seeing the linkage between emerging technologies, the U.S. private sector's participation in commercializing those technologies, and then finally letting those companies compete in a free and fair market against whoever we're competing against.

Mr. NELSON. Mr. Brumley, I don't think the Department of Commerce ought to be involved in the planning and design of the Space Station. This is a state-of-the-art extraordinary facility, and when you start getting another agency involved, that's going to slow up the decisionmaking process, that's going to raise up the cost of the Space Station, then you're getting right back into the same thing that we ran into with the replacement orbiter.

Mr. BRUMLEY. Mr. Chairman, if the private sector, if the business community tells the Department of Commerce that they don't feel that they can have any commercial activity in the Station as designed, isn't it our responsibility, whether it's in an interagency process or in a bilateral process, to pass that information on to NASA?

Mr. NELSON. Oh, indeed. That's input. That's not decisionmaking. You have just drawn your role in what you just outlined to Mr. Perkins as one of the decisionmakers in how it's going to operate.

Mr. BRUMLEY. No, I disagree with that, sir. What I said was we are part of the negotiating team, that's number one; and number two, we've had no other input, no one has shown us a design. There

is, however—NOAA has a polar platform that will be on the Station. We are not involved in the design of the Station.

What we are is having input with NASA, as you have just identified, to make sure that in their design they don't create a system that is actually antagonistic to what the business community may want to consider doing in there, in the Space Station.

Mr. NELSON. Well, there might be a value in recognizing an analogy. One of the great national assets of this country are our national laboratories, and a lot of the work product that has come out of those national laboratories has been extraordinarily successful in the commercial markets. We are getting ready to design an extraordinary new national laboratory. It's going to be 300 miles above the Earth, traveling at 17,000 plus miles per hour. Now, the Department of Commerce doesn't belong in there, trying to design it—yes, to utilize for commercial purposes the work product, but not in the decisionmaking process to put together and to come formulate policy as to what the Space Station is going to be. It all gets down to this matter of turf.

Mr. BRUMLEY. If all the space station is going to be is a national laboratory in space, then one of the goals of the station, meaning commercial activity, commercial manufacturing, if it is on the laboratory, as you describe it, is going to be frustrated because we even have regulatory imposed burdens on what kinds of things we can do in Federal labs here on Earth.

But if, and by the way, the Department of Commerce has a responsibility in that area—if it has the goal of being a national laboratory and 10 x 10 x 10 cubic feet of commercial space which people can come into and manufacture products, all we are saying is that it is no longer purely a national laboratory, any more than the shuttle was sold as purely a national transportation system.

It then becomes commercial. The question is, can we do that better? Can Government do that better or can the private sector do it better? And if the private sector can, keep your national laboratory but keep it clearly defined as such, and let the private sector develop the free flyers around it based on their own capitalization, their own desires for manufacture, and if they need to couple up to do tech transfer or do some kind of work with the national lab, then that's fine, but other than that, don't sell it as a commercial manufacturing facility, and unfortunately, it is not being sold as a national laboratory. It's being sold as all things to all elements of the business sector, the science sector, and that is what we have to react to, and that's where we base our inputs.

Mr. NELSON. What do you think ought to be your role in Max Faget's proposal which he has worked out with NASA? He worked that out with NASA. He didn't work that out with the Department of Commerce.

Mr. BRUMLEY. Absolutely.

Mr. NELSON. He is going to use it as a commercial enterprise in space. It's going to be the beginning of an industrial park in space. That's a commercial activity.

What do you think ought to be your role?

Mr. BRUMLEY. Whatever he manufactures there is going to require patent protection. If he's going to have Italians in that module making products, whose laws will apply, Mr. Chairman?

Will they be our laws or will they be the laws of Italy? He's going to make products to be imported back into this country, brought back here. If he happens to encourage Japanese joint ventures to make semiconductors there, they bring them back into the United States. Have they violated the semiconductor agreement or is that consistent with our trade laws?

Both of those are responsibilities of the Department of Commerce. We want to know, not to interfere, not to regulate, we want to make sure that Max Faget's commercial potential is realized and is not frustrated by this Government. That's all.

Mr. NELSON. Okay. If you keep yourself in that role, then you are not overstepping your bounds.

Mr. BRUMLEY. That's all we want to do, sir.

Mr. NELSON. Okay. Then remind yourself of that over and over when you start trying to chair this Commercial Space Working Group and your boss, Mr. Brown, gets on that SIG Space and he is a participant with the Administration—of NASA, determining whether or not we are going to have a space station and he's determining in SIG Space whether or not we ought to have a replacement orbiter. Remind yourself of your role.

Any further questions from any members?

[No response.]

Mr. NELSON. Mr. Brumley, do you have a question for either of these two gentlemen?

Mr. BRUMLEY. Not at all.

Mr. NELSON. And I assume either of you don't have a question for him?

Mr. GILLAM. No, sir.

Mr. STADD. No, sir.

Mr. NELSON. The meeting is adjourned. Thank you.

[Whereupon, at 5:20 p.m., the Subcommittee recessed, to reconvene at the call of the Chair.]

# 1988 NASA AUTHORIZATION

WEDNESDAY, MARCH 18, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 10:09 a.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good morning. Presently there is a caucus concerning the budget. Since I can't be in two places at once, we had to make some choices, and the choice was that with the budget in the chaos that it is in, that we decided that it was important for me to be over there to at least monitor the first part of the deliberations, and fortunately I was, because there were some misconceptions about the Function 250, which is the part that includes science and technology, and I was trying to help straighten out some of those.

Today, we're going to have another hearing in our series of the hearings on the authorization for NASA for fiscal year 1988, and our focus today will be on the Agency's space research and technology budget and then also on its budget for safety and quality assurance.

We're going to hear from Dr. Colladay and also from George Rodney, who is the Associate Administrator for the Office of Safety, Reliability, Maintainability, and Quality Assurance.

Now these are two of the most important offices within the Space Agency. Dr. Colladay's office is responsible for developing the cutting edge technologies that are required to keep this country preeminent in space. And over and over, we have heard people say, "Don't cut those budgets. Instead increase them."

We've heard the Paine Commission, the National Commission on Space, say, "Triple that research and technology budget for the sake of this country."

Naturally, Mr. Rodney's office is responsible for ensuring that all manned space activities are conducted in a safe manner, a reinvigoration and redetermination to safety after the experience that we all went through on January 28 of last year.

Now Dr. Colladay is going to be telling us about an important new program within his office, and this is called the Civil Space Technology Initiative. I am delighted to see that NASA has this program. It is the first step toward reversing a trend of erosion and neglect that has continued for too long in the funding of NASA's space technology programs.

For more than a decade, the percentage of NASA's budget that has been devoted for the development of advanced space technologies has been running at a level that is only about a third of what it was in the decade of the 1960's. Though these activities in earlier decades only consumed a relatively small part of NASA's overall budget, it was the energetic space technology development programs of the 1960's that have been largely responsible for American preeminence in space that we have seen over the past several years.

If this country were to continue its recent underfunding of this important activity, then the consequences would not only be undesirable, but they would be predictable.

So it is critical, in my judgment, that we reverse this trend before it is too late.

Now in Mr. Rodney's area of responsibility, his office was created in the reorganizations that occurred in the aftermath of *Challenger*. Prior to the accident, safety and quality assurance had been one of the subfunctions of the Office of the Chief Engineer. Now Mr. Rodney's office has been chartered to have these generic activities as its sole responsibility.

Personally, I believe that this reorganization was a very wise and important move on NASA's part, and I want Mr. Rodney to know that this subcommittee fully supports his activities. I hope that in the coming months that we will have the frequent interaction between this committee and your office, so that we can ensure what we're all trying to work toward, that we have as safe as possible future manned missions.

So we want to thank both of you for being with us today, and we will insert Bob Walker's statement in the record. Interestingly, the Republicans are caucusing at this very point, too.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS OF
REPRESENTATIVE ROBERT S. WALKER
RANKING REPUBLICAN MEMBER
SUBCOMMITTEE ON SPACE, SCIENCE AND APPLICATIONS
U.S. HOUSE OF REPRESENTATIVES

MARCH 18, 1987

Good morning, Mr. Chairman. I would like to join you in extending a warm welcome this morning to Ray Colladay, already an old friend of this subcommittee, and also to George Rodney, the new Associate Administrator of NASA for Safety, Reliability, Maintainability, and Quality Assurance, on the occasion of his first visit with us.

These two gentlemen head the offices that serve unique functions within NASA. Ray Colladay directs an opeartion that will serve as our passport to the future. The major present project within his office is the National Aerospace Plane. While that effort is in the jurisdiction of the Transportaion, Aviation and Materials Subcommittee, the Subcommittee on Space, Science and Applications continues to be deeply interested in the implications that this project will have on the future of manned space activities. Let me also take this opportunity to say that my personal interest in this project, an interest which will be more completely reflected when we mark-up the TAM authorization legislation in a few days, is to ensure that there is the full opportunity for prompt commercialization of this exciting new technology.

There are many people who see this project as the Orient Express, an advanced aircraft that would bring any spot on

the globe within two hours flying time. But I see a far greater contribution to humanity from this technology. The National Aerospace Plane will lead to a great leap forward toward the annual trillion dollar space based economy of the future. When we have fully developed this technology we will finally gain the opportunity to move men and material into low Earth orbit, and far beyond, at costs that will make the development of space infrastructure a very attractive economic proposition. That ability to cheaply launch large payloads into low Earth orbit will be translated into permanent colonies on the moon and Mars, the full economic exploitation of space resources, and the manned expolration of our solar system in the 21st century.

We are presently at a time of extreme budget pressures. Within the next few days we will see the Budget Committee mark-up the first budget resolution. We hear that there are strong pressures against both the replacement orbiter, and the space station funding. I believe that the NASA budget is in deep trouble in the Budget Committee this year. In fact, as this Subcommittee told NASA witnesses a few weeks ago, the space station may not get funded this year. At the very least, I expect that any space station funding will be held hostage to a full explanation of the need, and compelling justification for moving forward on the station program at this time. Because of the long lead time on developing manned space systems, typically fifteen years, we must move forward aggressively on the National Aerospace Plane if we

are to have it available to meet this nation's needs in the early years of the next century.

Let me now turn, for a moment, to the present problems facing NASA. George Rodney heads the office that represents our institutional assurance that when we return to manned flight, we will do so on a basis that will give us assurance that we have reduced the risks of space flight as far as we reasonably can.

I want to start Mr. Rodney's first session before this subcommittee with some words of appreciation and praise. He stepped into a job that required a full restructuring of the office, and the responsibilities he faces. The Rogers Commission was a strong critic of the SR&QA function within NASA at the time of the Challenger accident. The evidence fully suports that criticism. They characterized the problem as a "silent safety program." The truth is that there is evidence to support a charge that there was no functioning safety organization within NASA a year ago.

I am assured by the staff that things have changed remarkably within the past year. For that I congratulate Mr. Rodney. I, and all of the other members of this committee, will offer you our full support in your efforts. We have a strong commitment to ensuring that safety is our first concern.

Thank you, Mr. Chairman.

Mr. NELSON. So we will proceed, and, Dr. Colladay, if you would start out.

Thank you.

Oh, and by the way, you know the modus operandi of the committee. I don't want you to read your statement to us. Just talk. Talk to—I was going to say to us. Your written statement will be part of the record, so just talk to me.

**STATEMENT OF DR. RAYMOND S. COLLADAY, ASSOCIATE ADMINISTRATOR FOR OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Dr. COLLADAY. Thank you, Mr. Chairman.

I appreciate those positive and supportive words in your opening remarks about the importance of the research program in NASA. I will just briefly summarize a few of the main points that I would like to draw attention to in the statement for the record.

I have with me today Dr. Rosen, who is my deputy, behind me, and Dr. Harris, who is the Director of Space, to help answer any questions if I need that.

I do appreciate the opportunity to present NASA's Space Research and Technology budget request. Too often in the past, the research program has been taken for granted, I feel, or worse, been viewed as discretionary, something that could be bought by the yard or, in fact, cut by the yard. But there has been a change, as you observed. This request reflects a commitment to research and technology.

In the fiscal year 1988 budget we propose to begin the restoration of the technology base that was once the envy of the world and was the basis on which our leadership in space was built. Our space program began with the recognition that heavy research and technology investments had to be made to support a national commitment. Early investments brought new technology concepts that led to the success of the Apollo Program and the Shuttle Program.

We have been living off that early investment for a long, long time. We have let our investment in research and technology slip to a third of the level it once was as a percentage of the total agency budget. Meanwhile, other countries have not been standing still. They have been investing in research and technology as a way to stimulate economic competitiveness and provide national prestige that this cutting edge technology provides to those countries.

Every recent study, as you observed, that has dealt with the U.S. civil space program has pointed out the need for increasing research and technology investments in space. In the future, any scenario that you and I would want to construct must necessarily start with rebuilding the technology base.

This budget, with the civil space technology initiative, is the most positive step in the last 20 years in that direction, a positive start on building for our future. The program has been very carefully constructed with the help of our industry advisers, the university community and the researchers, who know what is possible, and the users, who know what is needed.

Out of a total space R&T budget request of $250 million, a $70 million augmentation is included for the civil space technology initiative in fiscal year 1988, and over the next five years that program will total $773 million.

There are three basic thrusts of the initiative. One is safe and efficient transportation to and within space. That deals with propulsion and aerobraking vehicles. The second category is Earth orbit operations, and that deals with automation and robotics and power. Third is science supporting technologies, dealing with advanced instruments and large precision structures.

Each element of this focused program is described in detail in the written statement, and I won't go into detail here.

I would like to add, however, that an important aspect of this augmented technology program is its positive impact on our people in the Nation's universities. It will help develop and stimulate our scientists and engineers by involving them in cutting edge research with a positive can-do attitude focused on the future.

It will also serve as a magnet for new talent fostered by increased involvement of our engineering schools.

In summary, technology and the solid research program that goes with it has been the cornerstone of our leadership in space. It is what has made NASA great and has attracted so many of us to this agency. Excellence in research and technology is a culture inherited from NACA. It is the basic roots of NASA.

This real and much-needed boost in the R&T program signals, I believe, a new recognition and awareness of that fact. The way I look at it, we are finally getting back to basics.

I would be happy to answer any questions regarding specific details of the request.

[The prepared statement of Dr. Colladay follows:]

STATEMENT

OF

Dr. Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to present NASA's FY 1988 Space Research and Technology (R&T) budget which reflects a reevaluation of NASA's technological capability to sustain leadership in space. We are especially aware of lessons learned from the past and of the role of technology in leading to a strong national civil space program in the future. Advanced technology is a prerequisite to sustained leadership, providing reliable options for the scientific and human exploration missions of the future. In FY 1988, we propose to initiate the Civil Space Technology Initiative to begin the restoration of the technology base to enable high priority future programs. I will discuss some of the factors which led to CSTI before describing its content.

The United States civil space program began with the recognition that heavy research and technology investments had to be made to support a national commitment. Early investments paid large dividends. New technology and new concepts were necessary before the United States proceeded with vigor into space. The concept of the high aerodynamic drag entry configuration and the heat shield for the Apollo Command Module, the development of cryogenic tankage and propulsion systems for the Saturn launch vehicle, and the development of life support systems and space suits were all required to assure the first successful human step on the moon by a United States astronaut. Then, in the mid-to-late 1960's, up-front research flights to verify the concept of low lift-to-drag ratio entry configurations, new reusable entry materials, and the technology for reusable propulsion systems were critical to the subsequent development of the Space Shuttle.

After peak investment in the early 1960's, the NASA Space Research and Technology budget fell so precipitously, Figure 1, that within 10 years we dropped from a 6-percent level of investment to about 2.5 percent of the NASA space R&D budget. In terms of constant purchasing power, our budgets were reduced to 15 or 20 percent of what they had been.

During this same period, investments abroad in France, Italy, Germany, Japan, China, the Soviet Union and other countries have not been standing still. Competitive products across a broad range of space endeavors have been, and are being, developed through extensive research investments. These foreign products range from launch vehicles, to commercial communications satellites, to science missions, and now to the prominent Russian space station. What was once an unquestioned area of U.S. preeminence--the civil space program--is now increasingly a field with shared leadership.

Every recent study on the U.S. civil space program has pointed out the need for increasing research and technology investments in space. The National Commission on Space; a Space Science Board study, "Twenty-Year Forecast of Space Science, 1995-2015"; and a joint DOD/NASA study in response to a National Security Study Directive on technology required for future space transportation systems, all strongly call for a greater national investment in research and technology to support a wide spectrum of applications.

The last year was a period of tragedy, reflection, and rebuilding. It continues to be a period of recovery for NASA, reconstituting Shuttle capability, maintaining Space Station momentum and resolving the science mission backlog. But, if recovery is to be lasting, we must start now to rebuild the technology base. The Civil Space Technology Initiative (CSTI) that we are proposing in FY 1988, Figure 2, will begin to restore the technology base as a first step in building for the future. It is focused on technology gaps that fall within three broad categories: research in technologies for safe and efficient access to space, for earth-orbiting operations, and for future science missions.

In transportation, launch vehicle propulsion research will be aimed at reusable, high-performance engines for next-generation vehicles. A new booster technology program will develop options for both hybrid and pressure-fed propulsion systems; and, an aerobraking flight experiment will demonstrate use of the atmosphere to slow an orbit transfer vehicle returning to low Earth orbit at high velocities.

Earth-orbiting operations capability will be enhanced through a continued and expanded effort in automation and robotics. The research emphasis includes autonomous systems for control of multiple subsystems such as the capability for reasoning and recovery from failures; launch system software to replace routine,

labor-intensive activities; and robotics for remote assembly, repair and servicing of space vehicles; and a high capacity power program.

Supporting technology for science will include research in large structures and their control, large segmented reflectors for future observatories in space, sensor research for earth observations and astrophysics, and data research for onboard processing for large data-demanding systems.

The FY 1988 Space R&T budget request of $250 million, Figure 3, includes a first year $70 million augmentation as a part of CSTI. CSTI totals $773 million over the next five years and focuses on research in propulsion, vehicle, information systems, large structures and control, power, and automation and robotics. In the transformation from the FY 1987 budget, the FY 1988 program has been restructured into two parts. The first part is the R&T Base which will retain the generic discipline orientation of the past and provide the seedbed for new ideas and a stronger university program. The second part, which is CSTI, is a redirection of some ongoing programs and includes a substantial augmentation.

The CSTI program was selected and structured on the basis of leadership strengths, expertise, facilities, missions, industry and university input, and availability of conceptual data and studies from past R&T Base research. The character of each of the elements of CSTI is to provide crucial data and to verify new concepts at a sufficient level so that the technology can be considered ready to apply.

Transportation: Figure 4 shows the future of space transportation expected with advanced technology leading the way from the Space Shuttle and current generation expendable vehicles to partially reusable cargo vehicles and new fully reusable manned vehicles. In the future, advanced technology will provide the foundation for realistic decisions among advanced rocket and air-breathing systems enabled by the National Aero-Space Plane program.

In earth-to-orbit propulsion, we will continue, in cooperation with NASA's Office of Space Flight, to assemble the LOX/hydrogen test-bed engine using Space Shuttle Main Engine (SSME) hardware. The test-bed engine will be used to validate internal computational fluid dynamics codes; to verify advanced long-life, fault-tolerant component designs; and to demonstrate diagnostic sensors and health monitoring instrumentation. Analysis methods and concepts are developed and initially evaluated in rig testing in the R&T Base, but the test-bed engine is required to provide data in the true engine environment, which cannot be simulated in rig testing. Shown in Figure 5 are the locations of advanced sensors and instrumentation to be evaluated in the test bed. These include bearing wear detectors; turbine blade temperature sensors; optical hot gas

temperature sensors; nonintrusive cryogenic flow meters; and high-response, capacitive-type pressure transducers. Advanced long-life components scheduled for early verification testing include longer-life bearing designs and single crystal turbine blades. Although the program will support the ongoing SSME advanced development program, its primary objective is to provide the data base and analytical techniques for future high-performance, reusable LOX/hydrogen, LOX/hydrocarbon, and dual fuel engine developments.

For over 10 years, the NASA R&T Base program in hydrocarbon propulsion has been building an understanding of ignition, combustion stability and heat transfer through analyses and laboratory experiments. In FY 1987, the budget for research in hydrocarbon propulsion was doubled. In FY 1988, CSTI research will continue laboratory scale testing and will begin efforts to test large-scale, high-pressure combustors, Figure 6.

The objective of the booster element of CSTI is to evaluate two alternatives (the pressure-fed liquid bipropellant and the solid-liquid hybrid) to the solid rocket motor for future transportation applications. Solid propellant motors, such as those used on the Shuttle, would require complex design and operational techniques to achieve thrust termination capability before complete burning of the propellant. Figure 7 shows a sizing comparison of conceptual pressure-fed and hybrid propulsion systems to replace the solid rocket motors on the Shuttle configuration. Either concept would use standard propellant tank construction technology. The hybrid booster technology will establish solid fuel formulation, ignition, internal surface burning characteristics, liquid oxygen delivery techniques, and thrust termination concepts. Small- and large-scale firings will be used to verify performance predictions and start and shutdown characteristics. Pressure-fed boosters could use liquid oxygen with hydrocarbon or hydrogen for propellant. After propellant selection, combustion stability, pressurization system and materials compatibility studies will lead to a series of firing tests to verify performance predictions. The experimental verifications will result in performance parameters which could be used in future designs with the two alternative booster systems.

To complete the near-Earth transportation system, Figure 8, shows a conceptual configuration for a fully reusable, space-based orbit transfer vehicle. The configuration is tailored to the aerobrake concept. Our studies show the advantages for a reusable, space-based Orbit Transfer Vehicle (OTV) for operations between low Earth orbit (LEO) and geosynchronous Earth orbit (GEO). Application of the aerobrake concept to the OTV on return to LEO has the potential for increasing the payload by a factor of two. This is achieved by replacing propellants and related tankage with a control system and a passive lightweight deployable aerobrake heat shield. The aerobrake allows atmospheric drag braking in the upper levels of the atmosphere on return to LEO. To realize the potential benefits

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of the aerobrake, aerodynamic and aerothermodynamic predictions and lightweight structures and heat shield materials must all be verified in the actual entry environment. The Aeroassist Flight Experiment (AFE) will be flown for this purpose. As shown in Figure 9, the aeroassist test vehicle is taken to low Earth orbit by the Shuttle, released, and accelerated downward into the Earth's atmosphere to a velocity of 33,000 feet per second which simulates a return from geosynchronous orbit. The aerobrake maneuver is performed at approximately 250,000 feet above the Earth's surface and the vehicle flies back to low Earth orbit where it will rendezvous with the Shuttle for return to Earth.

Key aerobrake technologies to be flight tested and demonstrated have been studied for a number of years in the R&T Base. Uncertainty exists over the total heat load these types of vehicles will experience as well as on the control and stability of the vehicle. These issues can be resolved with the proposed flight experiment. A new computational method for predicting aft-body flow field impingements and heating and a thermal protection system has been developed and verified in wind tunnel tests in 1986. Advanced aerobrake materials must be capable of repeated reentry cycles after unfolding to the appropriate aerodynamic configuration.

Operations: Operations in space, as shown in Figure 10, will become an efficient mix of humans, machines, and autonomous robotic devices. In this environment, satellite and facility maintenance and resupply will be typical operations requirements.

The ongoing Automation and Robotics program has been incorporated into the CSTI program and expanded in FY 1988. The objective of this research is to exploit the potential of artificial intelligence and telerobotics to increase the capability, flexibility, and safety of space and ground operations while decreasing associated costs.

The robotics element of CSTI has the specific objective of reducing the time and level of human supervision from direct human control to teleoperations and eventually to high-level, goal-oriented supervision with minimal human intervention. In FY 1987, the preliminary design and development of the space robotics demonstration facility with a two-arm manipulator will be completed. The robot will acquire, de-spin, and service a spacecraft model with two cooperating, robot manipulator arms, as illustrated in Figure 11. Two recent accomplishments are the development of the hierarchical computer architecture which will allow artificial intelligence planners to control the robot and the completion of a prototype single-channel programmable image feature extractor which provides the real-time acquisition, feature extraction and tracking, motion stereo, stereo matching, and processing of visual images for the robot.

The objectives of the autonomous systems element are expanded to include research on pre-launch and post-launch operations. Figure 12 illustrates autonomous systems research that will explore approaches to automating electrical and pneumatic functions of the Orbiter on the pad. Figure 13 illustrates application of autonomous systems for intelligent control of on-orbit Shuttle communication systems. The intent is to use actual operations as a research test-bed simulation for autonomous system concept verification.

Mission studies have shown that high-capacity power for utility-like systems is essential for future Earth orbiting space stations, lunar and planetary transportation and bases, and high-performance propulsion systems for outer planet transport vehicles. Nuclear systems are expected to play a key role in meeting future power and propulsion needs. Figure 14, shows the main components of a conceptual high power system, including a reactor, radiation shield, thermal-to-electric power conversion system, heat rejection system, and power distribution system. The ongoing joint DOD, DOE and NASA SP-100 space nuclear power program is in the ground development phase with the objective of demonstrating a space compatible nuclear reactor system and a companion conversion system using a passive thermal-to-electric device with 3- to 4- percent conversion efficiency. In CSTI, we will augment ongoing research on the Stirling cycle dynamic thermal to electric power conversion system. The objectives are to establish the feasibility of a five-fold increase in the amount of electric power that can be generated from an SP-100 size reactor and a doubling of its power-to-weight ratio.

Science: As shown in Figure 15, large earth observing platforms with new sensor devices and data processing to provide useful information in real time to multiple ground sites will enhance our understanding of the earth and its habitability. The CSTI element in sensor technology will enable observations of terrestrial, planetary, and astrophysical phenomena outside the limits of current instruments. Three activities (sub-millimeter technology, active solid-state lasers, and sub-Kelvin cooler technology) make up the sensor program. In submillimeter device research, components such as mercury-cadmium-telluride alloy frequency mixers for heterodyne detection in the far infrared portion of the frequency spectrum have been fabricated and tested. Preliminary experiments on a superconducting-insulating-superconducting mixer using a new material (niobium nitride) show promise for a mixer at previously unattainable longer wavelengths of up to 600 micrometers. The CSTI thrust in the submillimeter technology area will eventually lead to a remote sensing instrument with simultaneous spectral and spatial imaging with immediate terrestrial, planetary, and astrophysics application.

Under laser research, Figure 16, advances have been made in solid-state replacements for unreliable flashlamps, which pump solid-state laser rods and enable active laser remote sensing

systems from space. Lifetimes of two years or longer are necessary to acquire the data base for future terrestrial and planetary climatology missions. Major advances in tuning, efficiency, and spectral purity of titanium-doped sapphire lasers have been achieved by Langley Research Center, industry, and academia. The CSTI thrust in the laser-active remote sensing area is to develop the technology, materials, amplifiers, oscillators, and detectors, for a space qualified laser system for both terrestrial and planetary applications.

The third sensor research area will establish a new capability to cool far infrared detector components to sub-Kelvin temperatures. This is required for imaging in a low thermal background such as that found looking out into deep space. Past research has verified that the concept of employing magnetic bearings in a linear Stirling cycle cooler should increase the lifetime to five years and lower the temperature of a one-stage cooler to 45 degrees Kelvin. A second-stage solid-state cooler based on techniques such as adiabatic demagnetization will be developed to produce temperatures below 1 degree Kelvin.

The objective of the data element, as shown in Figure 17, is to provide the technology for onboard data processing and analyses so that ground systems deal only with relevant information or restricted sets of important data. In previous R&T Base research on methods for processing high volumes (up to 50 million bits per second) of space-derived scientific data on the ground, we have provided a sound technical basis for "smart" onboard information systems. A combination of high-speed, special purpose processors and high capacity data storage devices is required if we are to avoid excessive demands on ground communications, storage and processing. The CSTI high rate/capacity data research will verify new concepts for onboard image processors to deal with massive data volumes of up to 400 million bits per second from synthetic aperture radar, visual, and focal plane instruments.

CSTI data research also includes verification of a read/write high capacity (a trillion bits) erasable optical recorder. This unit could store images for overlays and comparisons and provide buffering during periods of ground communication obscuration. Last year in the R&T Base, we took a major step in achieving the high data rates and capacity optical storage by producing and testing a nine-element laser diode array read/write element.

Future space missions will require very large, erectable and deployable space structures for a number of future applications. New telescope devices, such as that shown in Figure 18, will be orders of magnitude more sensitive than current space devices and orders of magnitude larger. Concepts of very large baseline interferometers to capture faint signals from distant bodies will greatly increase our understanding of the universe. These

structures must provide very stable support, but they will be very flexible because of demands for low weight and large size. Therefore, we initiated the Control of Flexible Structures (COFS) program in FY 1985 as a series of in-space experiments to provide fundamental data on structures and control concepts which cannot be obtained in ground laboratories because of gravity loading. In CSTI, we have coupled the COFS flight program with appropriate discipline activities of the R&T Base to achieve a comprehensive research activity which includes analytical methods development, component development, ground-based testing, and in-space verification. The COFS I experiment, as shown in Figure 19, consists of a large 60-meter deployable/stowable joint-dominated truss structure, called MAST, which will be dynamically tested in space cantilevered from the Shuttle payload bay. The MAST is currently under development. The first flight experiment is manifested for 1991.

Future space missions also call for very large, very precise reflectors for telescopes and interferometers. An example is the reflector for the infrared and submillimeter astronomical observatory being considered for the mid-to-late 1990's. Current planning is for a reflector 20 meters in diameter, similar to the concept shown in Figure 20, with a surface smoothness accuracy of 1 to 2 microns. Structures of this type exist on earth, but they are very heavy with glass reflecting surfaces and massive supporting structures for stiffness. A space-based system must be stiff enough to minimize surface disturbances, lightweight and dimensionally stable under nonuniform heating conditions, and will be actively controlled to assure panel alignment. Furthermore, the system must be fabricated in segments for transport to orbit for assembly and operation.

In the ongoing R&T Base, we have started research on high precision, lightweight composite reflector panels with the goal of producing panels 1 to 2 meters across weighing less than 10 kilograms per square meter. A small 0.4-meter panel has been fabricated which weighs less than one-third of a comparable glass system and has an average surface smoothness of about 0.5 microns. While this small-scale panel surpassed goals in weight and density, the design concepts must be tailored to larger scale while ensuring for surface accuracy, space durability, and thermal dimensional stability. As part of CSTI, a structure and control verification test of a multi-element reflector will lead to the selection of a single concept.

Summary:

Historically, technology has been a cornerstone of our leadership in space. What was once an unquestioned area of U.S. preeminence--the

civil space program--is now increasingly a field with shared leadership. As illustrated in Figure 21, technology is the means to many ends and CSTI is a first and affordable step focusing on technologies to enable advanced transportation to and operations in Earth orbit and to enable next-generation science missions. The initiative is founded on a decade of R&T Base research in emerging technologies and meets identified priority needs of NASA and national programs. It will stimulate our staff by providing increased involvement on cutting-edge research and technology with a clear direction for the future. Our engineering universities will also be positively motivated to increase research activities supporting our future in space and to provide a magnet for new talent.

I believe the FY 1988 NASA budget request is a first step in restoring the research and technology leadership that is required in space; and, most important of all, the timing of CSTI is fundamental to providing a long-term basis for the recovery of the Nation's space program. We appreciate this Subcommittee's continued support and commitment to space research and will continue to do our best to keep this Nation second to none.

Thank you, Mr. Chairman. That completes my testimony. I would be happy to answer questions.

# SPACE R&T

## PERCENTAGE OF AGENCY SPACE BUDGET

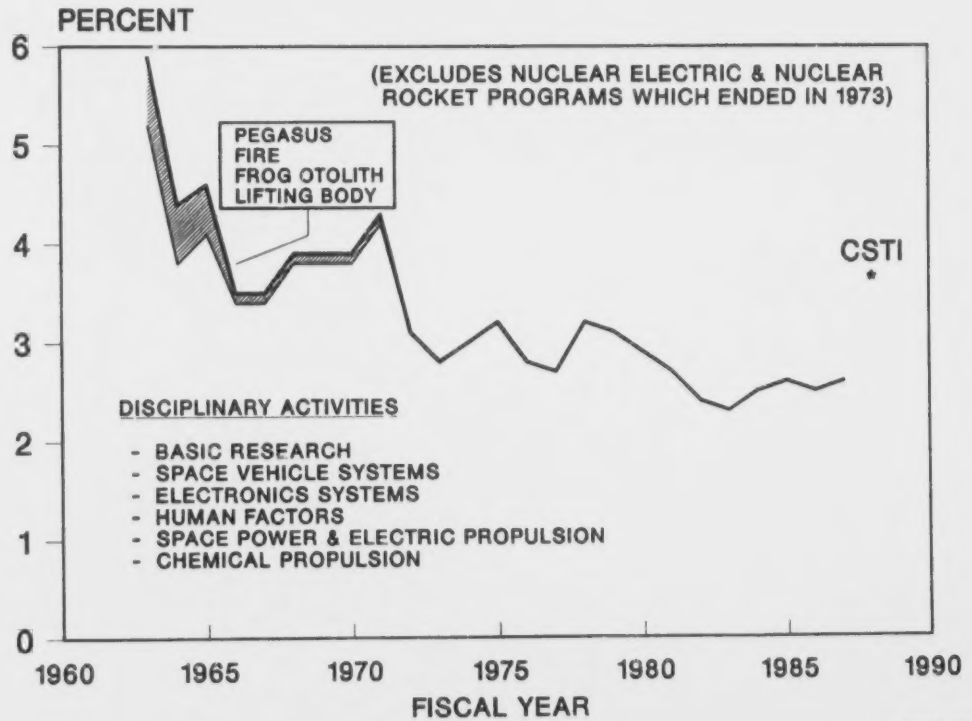



Figure 1. Space R&T Funding Trend

RS87-1151

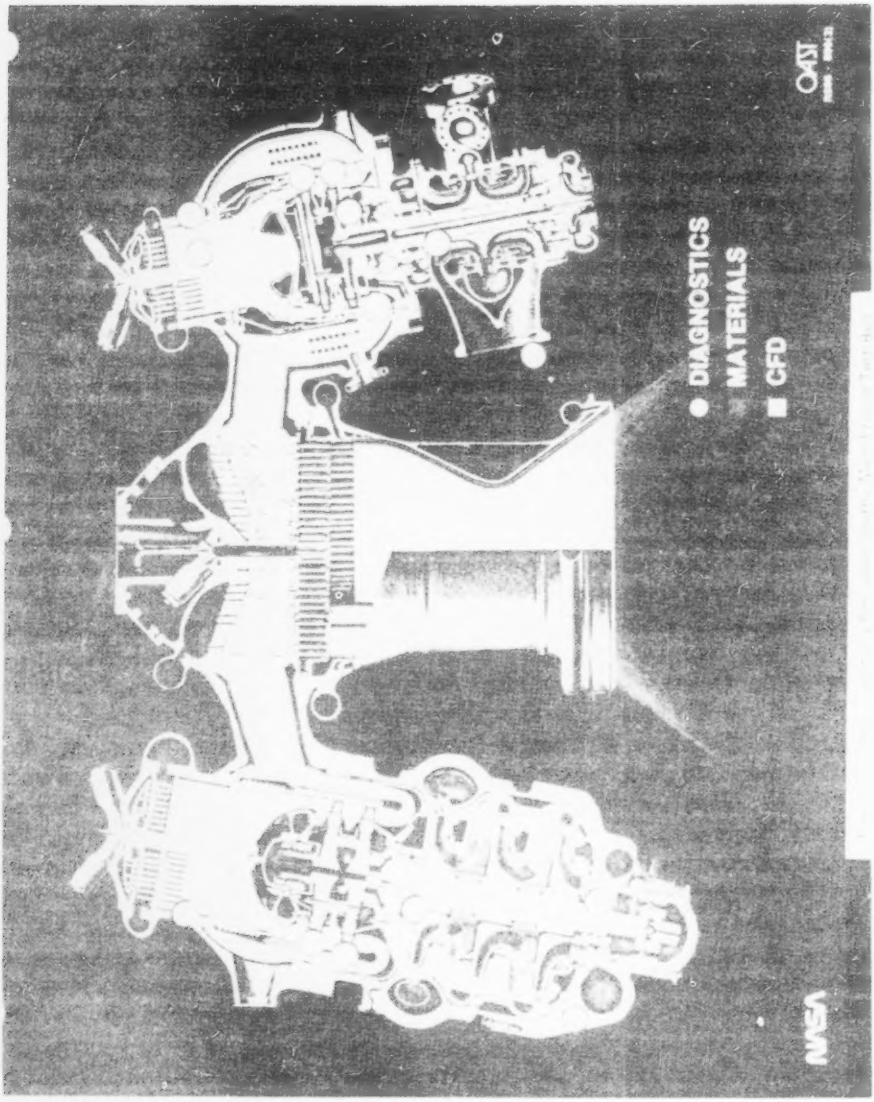
CIVIL SPACE TECHNOLOGY INITIATIVE
SCIENCE
OPERATIONS

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

### R&D BUDGET
### ($,M)

| | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|
| SPACE RESEARCH & TECHNOLOGY | 151.4 | 171.0 | 250.0 |
| R&T BASE | 124.2 | 133.6 | 115.9 |
| SYSTEMS TECHNOLOGY | 27.2 | 37.4 | — |
| CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) | — | — | 134.1 |
| PROPULSION | — | — | (39.2) |
| VEHICLE | — | — | (15.0) |
| INFORMATION | — | — | (17.4) |
| LARGE STRUCTURES & CONTROL | — | — | (22.8) |
| POWER | — | — | (14.0) |
| AUTOMATION & ROBOTICS | — | — | (25.7) |

Figure 3. Civil Space Technology Initiative (CSTI) Budget


NASA
● DIAGNOSTICS
■ MATERIALS
■ CFD
OMST

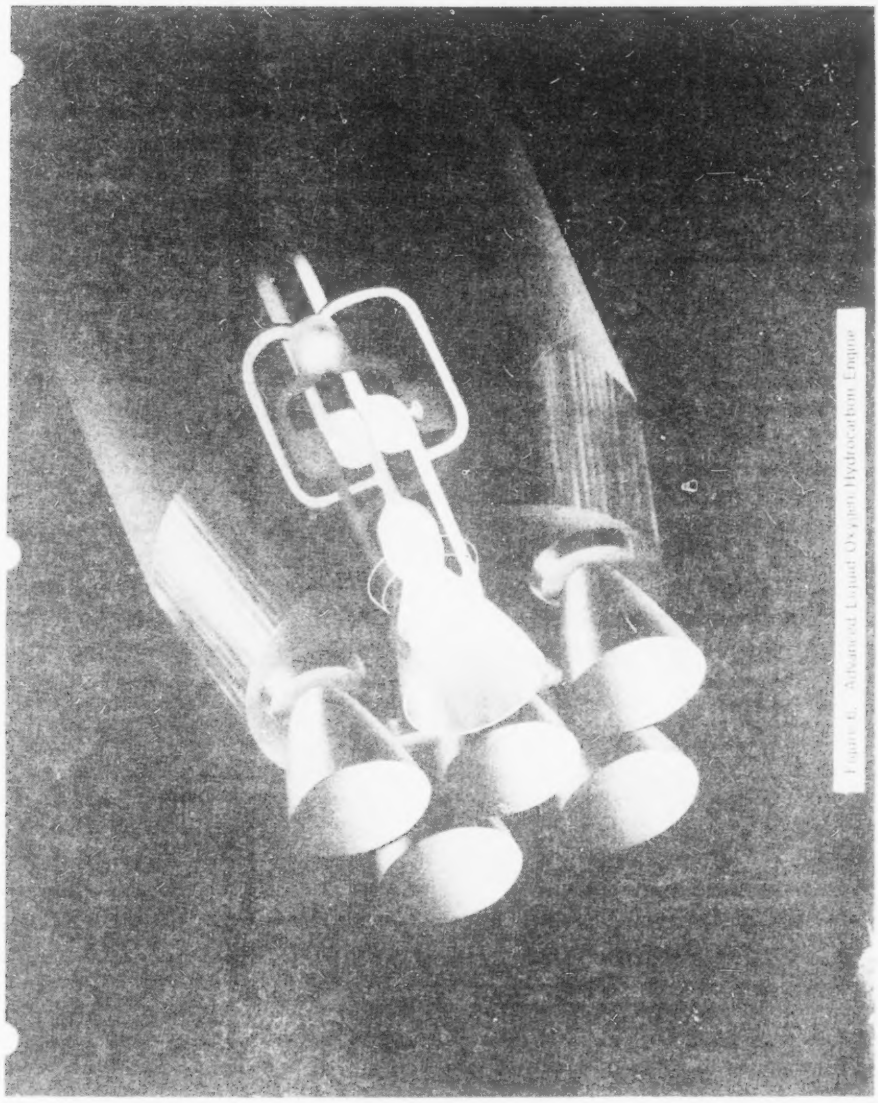
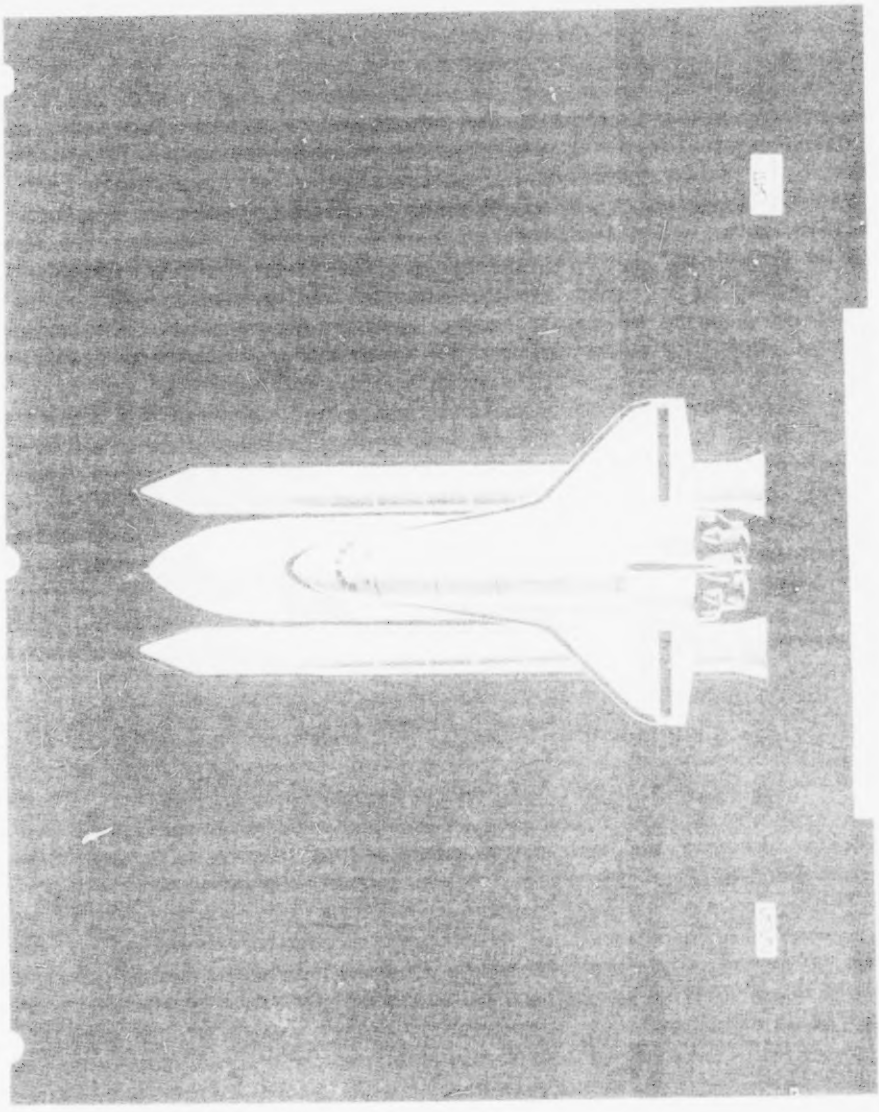
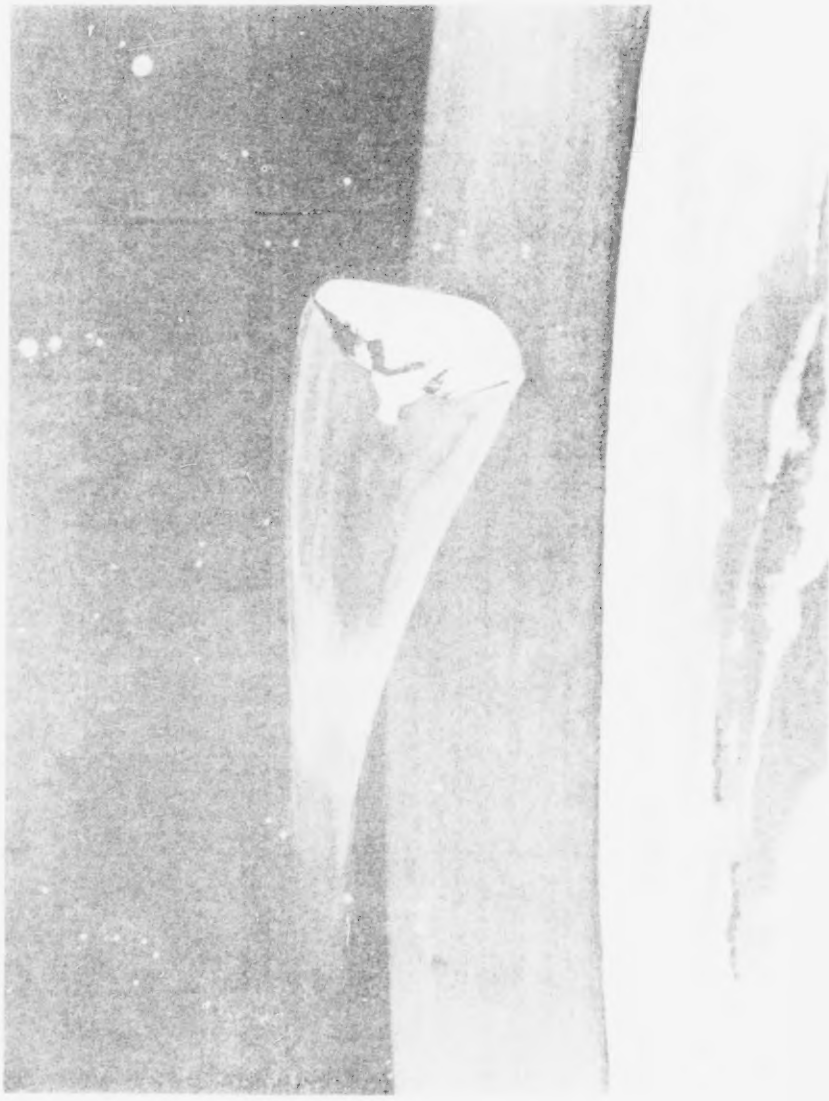


Figure 6.—Advanced Liquid Oxygen-Hydrocarbon Engine





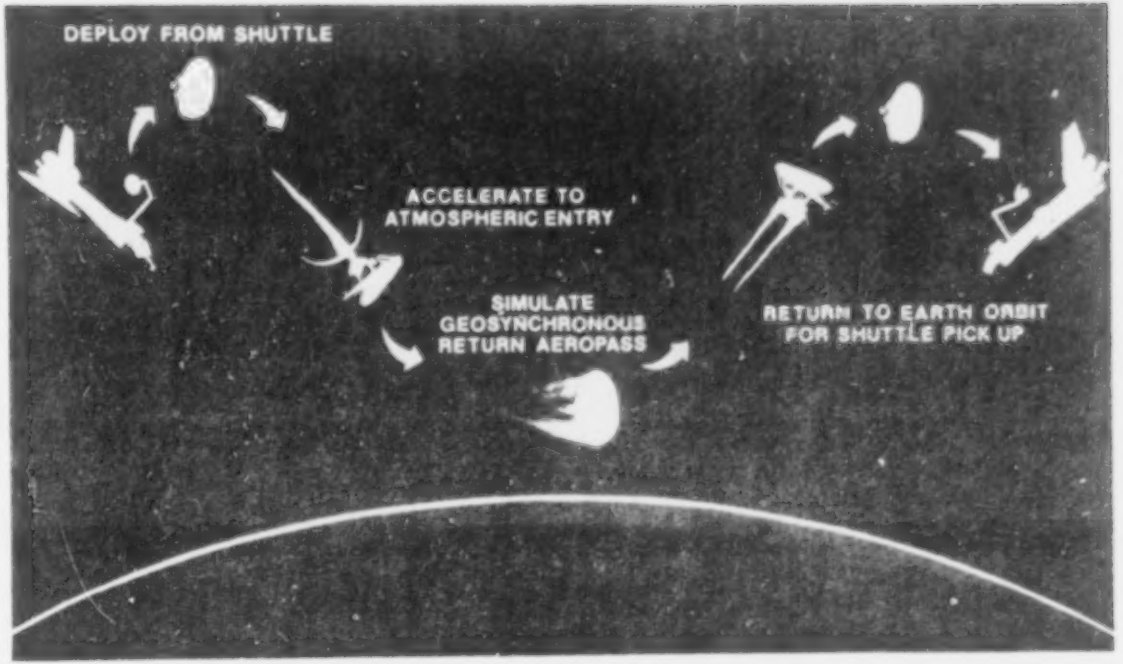
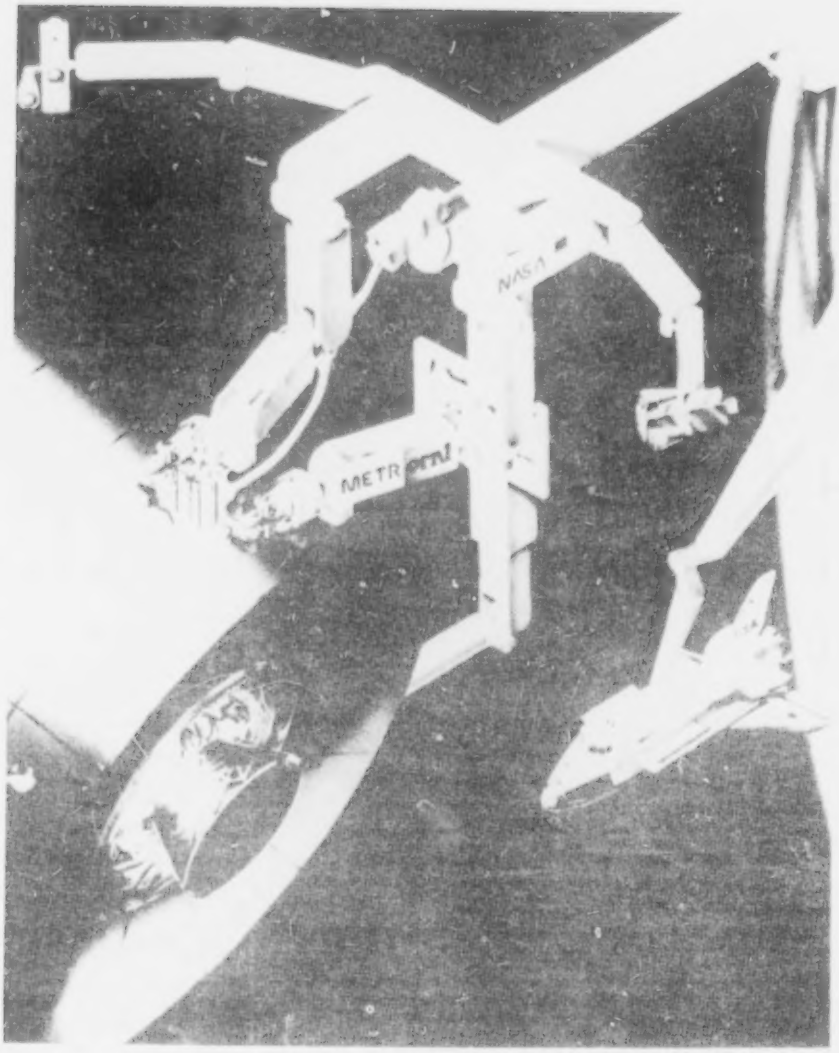



Figure 9. Aeroassist Flight Experiment (AFE)


NASA

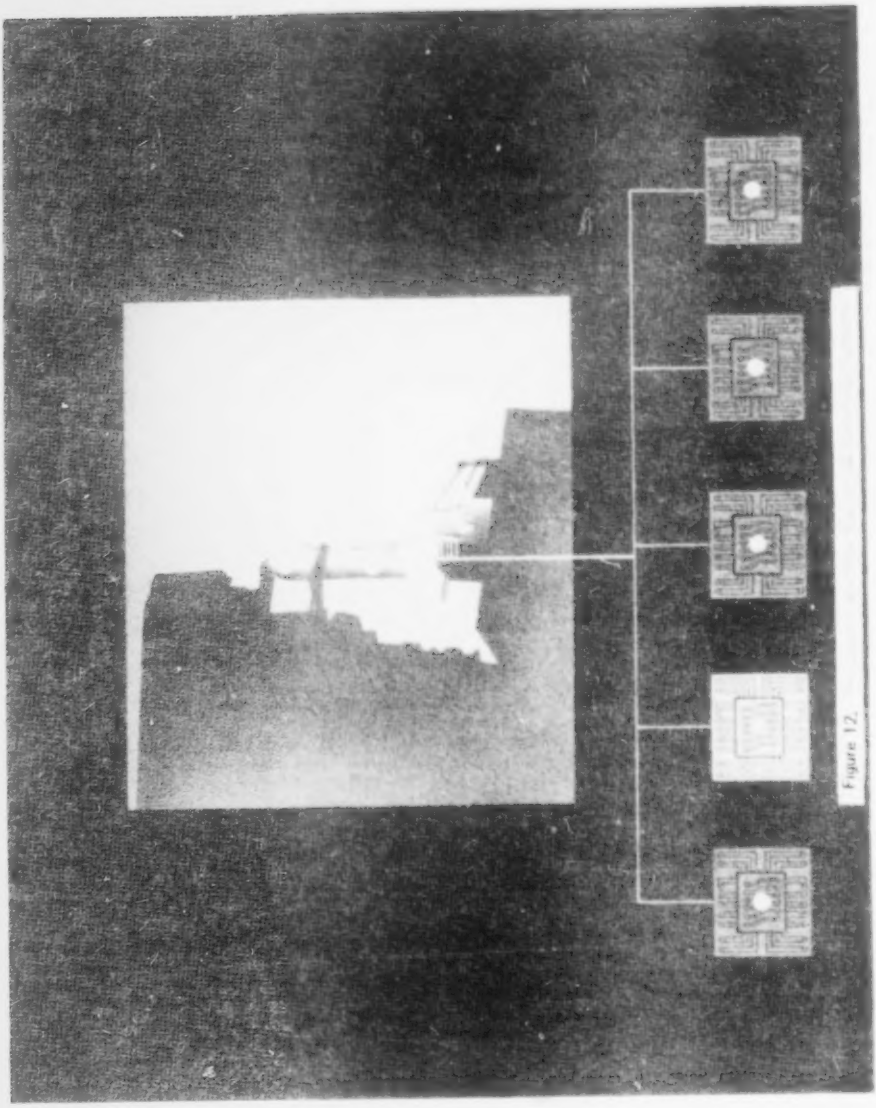


Figure 12.

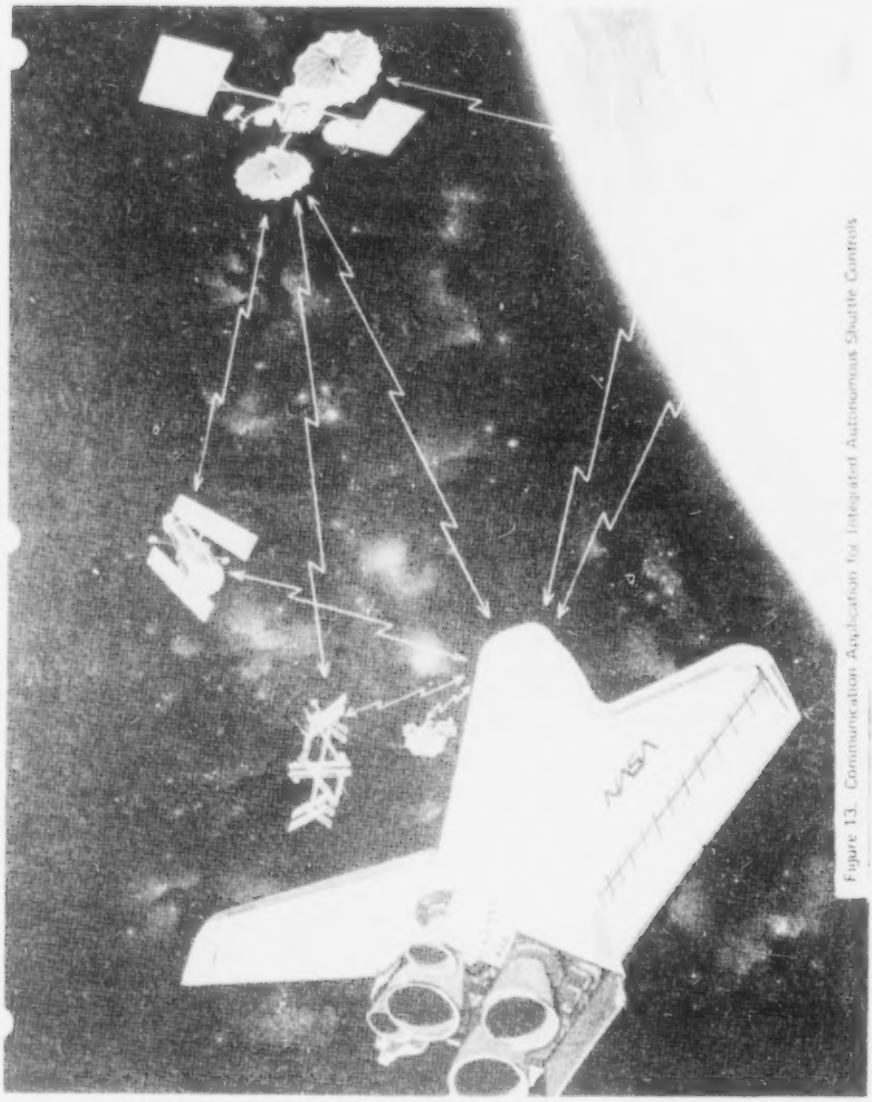
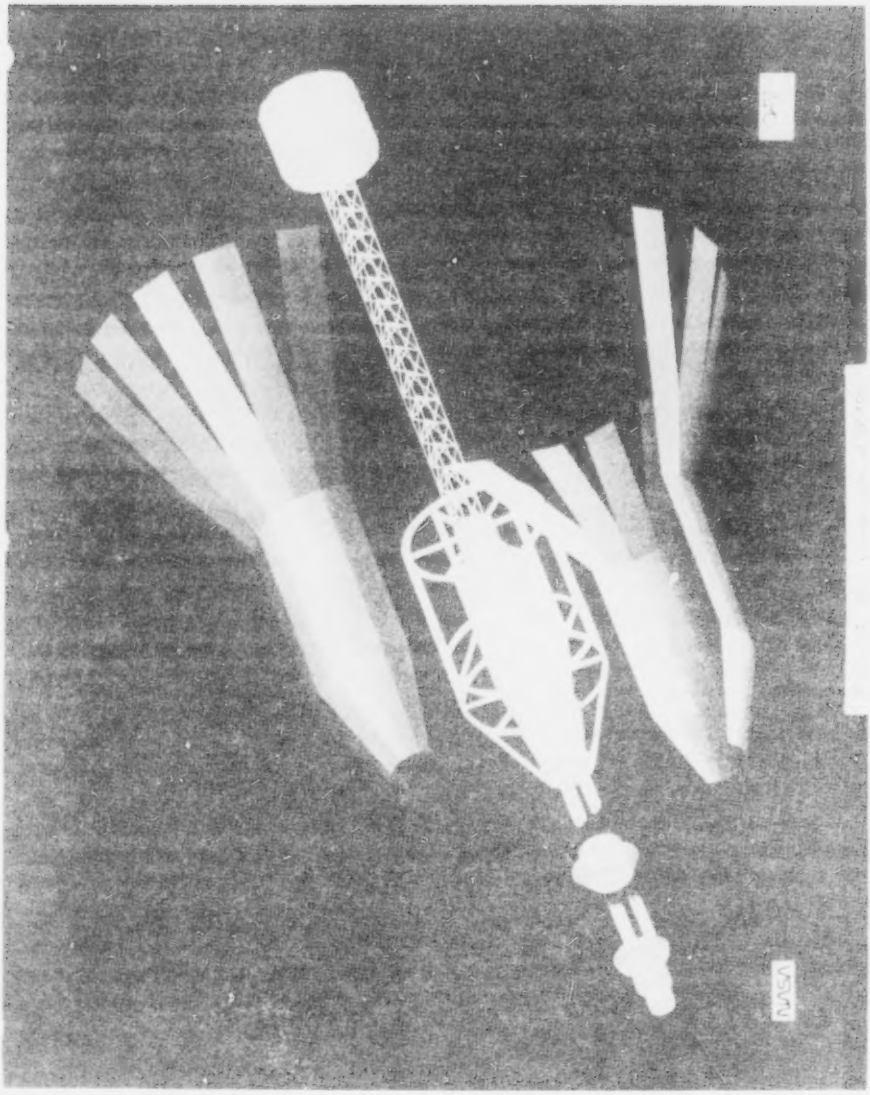
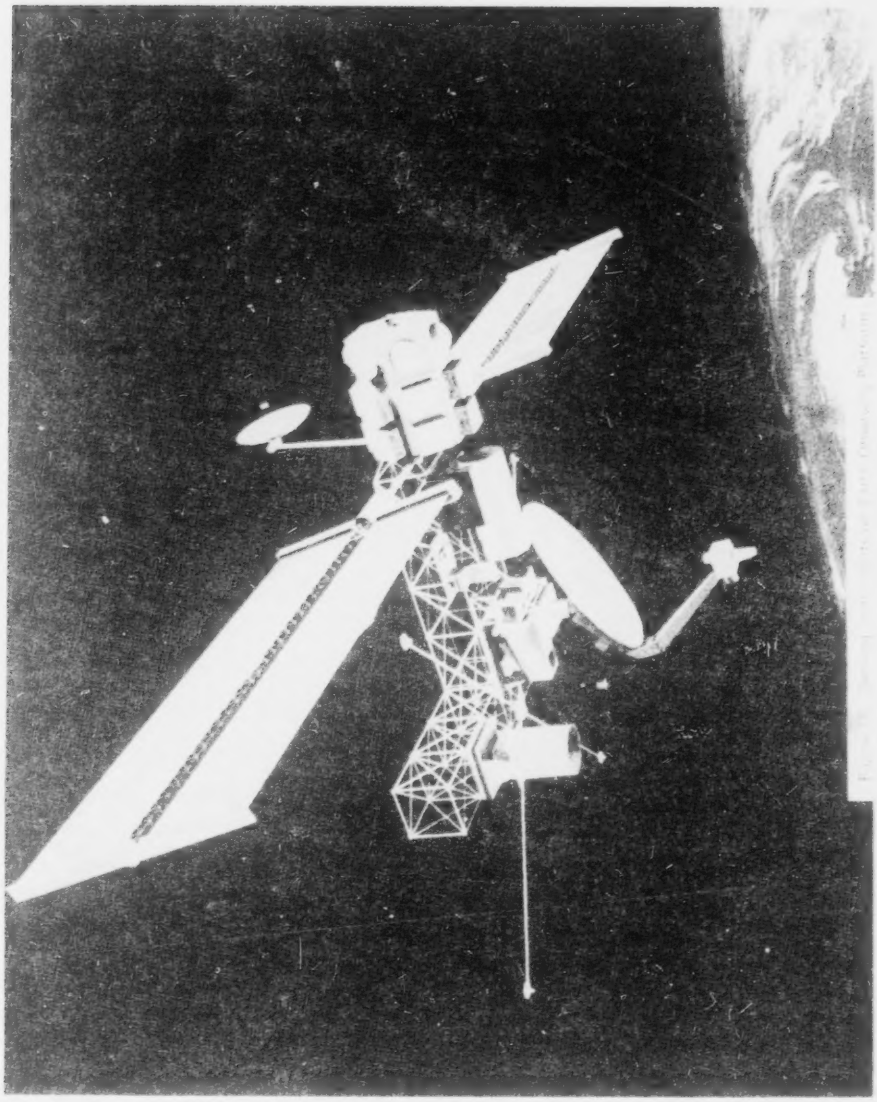


Figure 13. Communication Application for Integrated Autonomous Shuttle Controls





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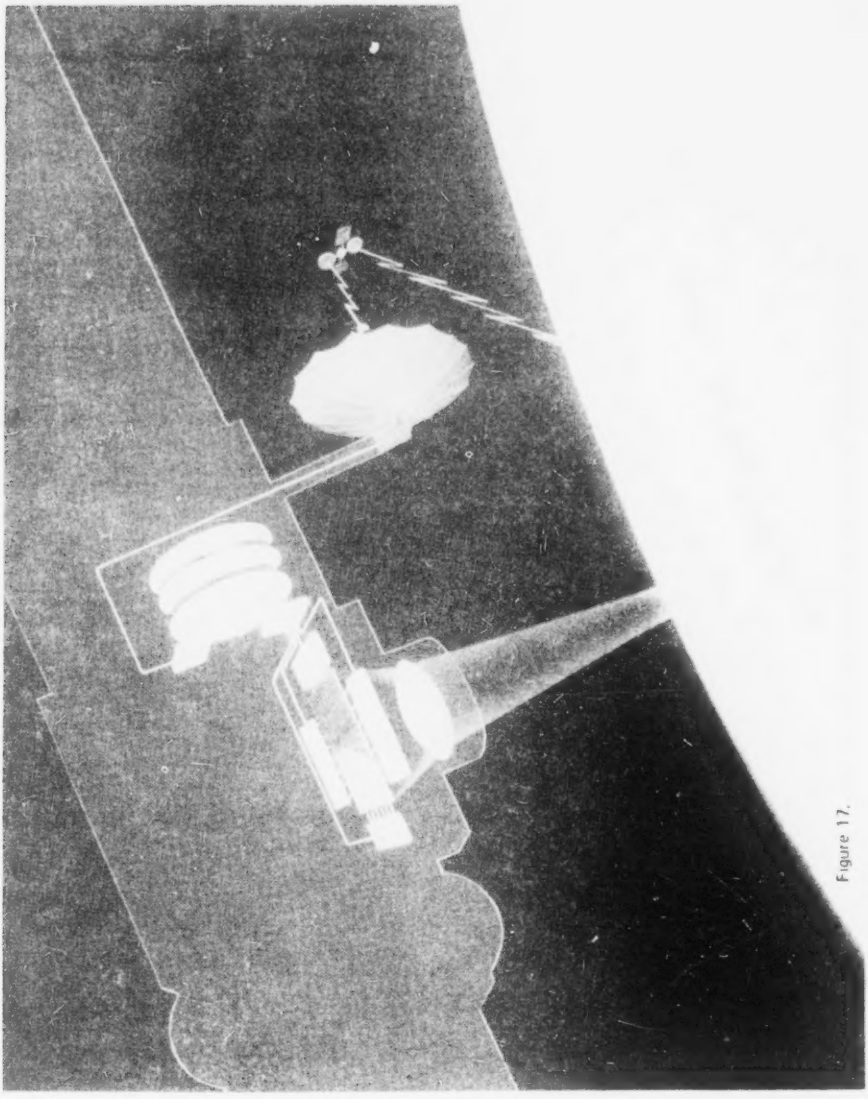
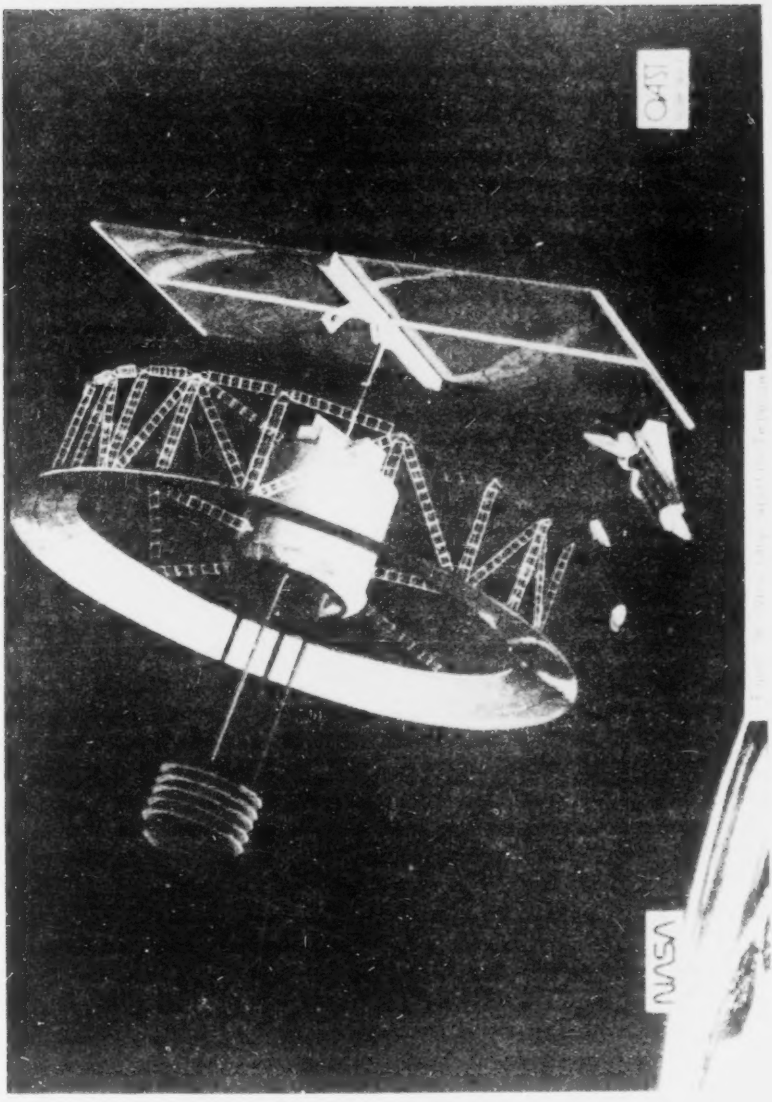


Figure 17.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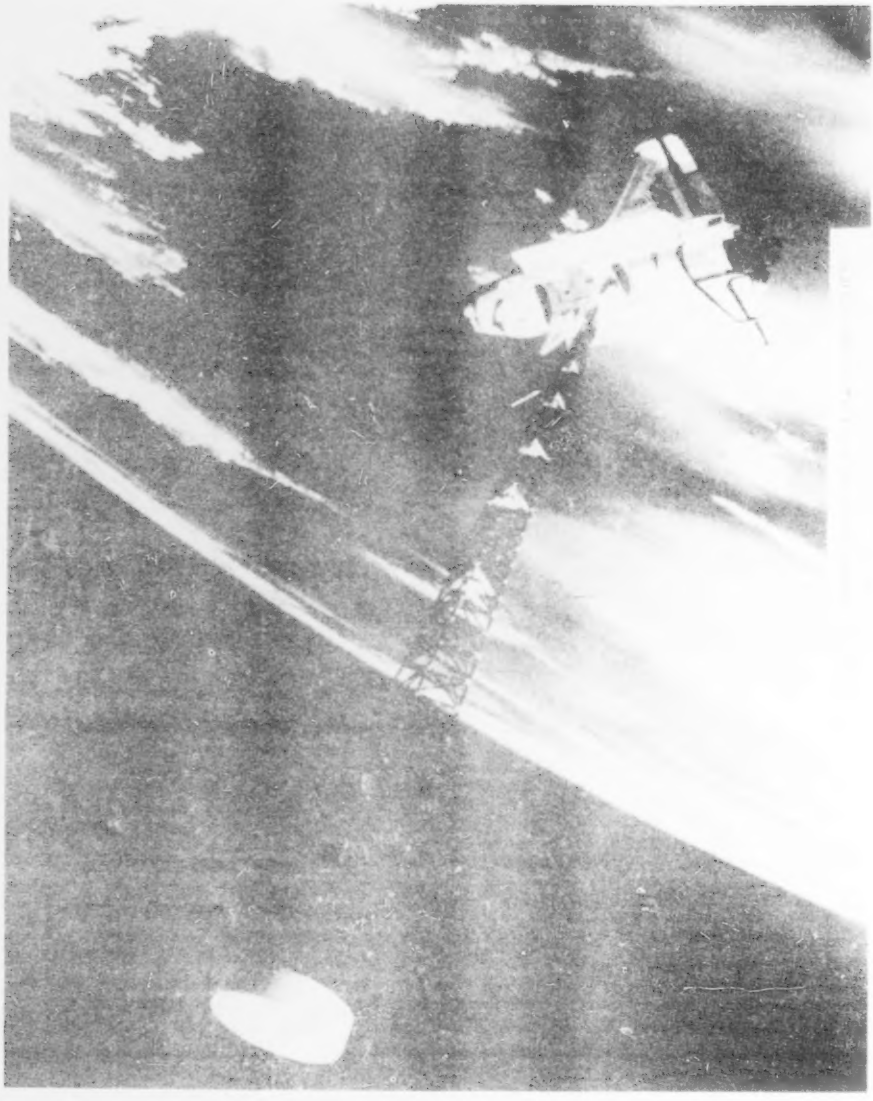


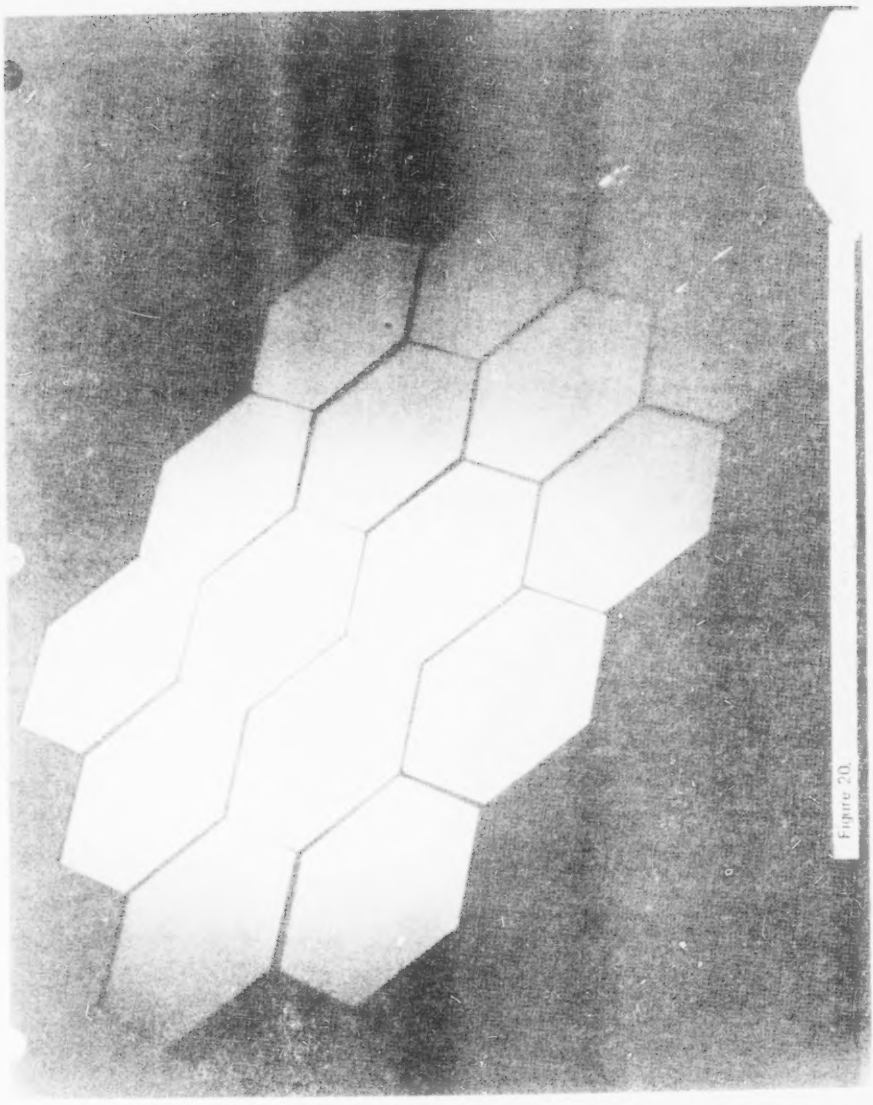
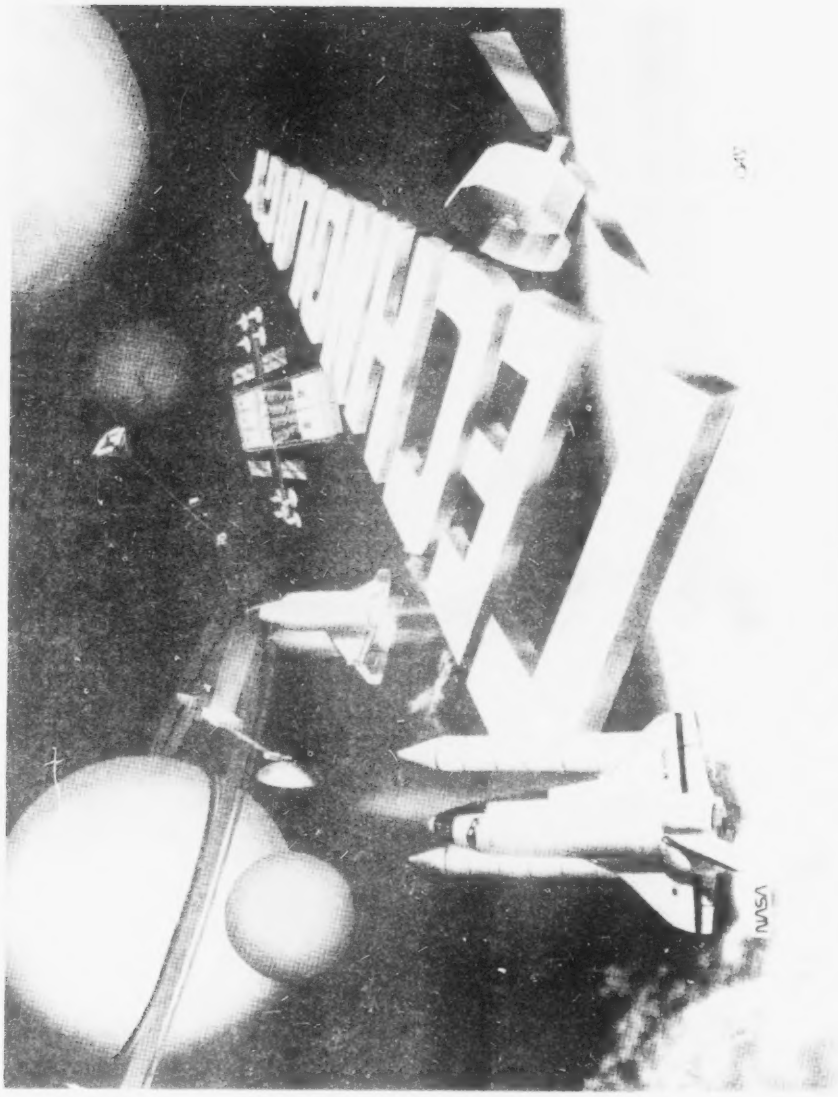


Figure 20.


NASA

Mr. NELSON. What about the human factors? I notice you have got a doubling there.

Dr. COLLADAY. We did increase the level in the R&T base, what we call the base technology, in human factors because of the need to have a stronger base of support for focused life science and life support systems that were planned for the more focused initiative. We need to increase our efforts in human factors and the whole area of long duration human exposure for missions like Mars and lunar bases and others that we are planning.

Mr. NELSON. When this committee was in Moscow in October of 1985, we noticed that they had some enclosed modules that basically the Soviets were working on those human factors by enclosing a crew for more than a year. Do we have anything comparable going on in this country?

Dr. COLLADAY. We do have research in the laboratory setting like that, Mr. Chairman, at our Ames Research Center where we do our basic human factors work. We are hoping to build a human performance laboratory as part of the request of the fiscal year 1988 budget.

Mr. NELSON. Is that what this thing would be?

Dr. COLLADAY. That is right, and that started from the core of human factors work that we have been doing for many years in aeronautics at Ames Research Center, and the human performance laboratory would give us considerable extended laboratory capability of what is now done on a very small scale.

Mr. NELSON. Mr. Hefley.

Mr. HEFLEY. I don't have any questions, Mr. Chairman, and I apologize for being late.

Mr. NELSON. We know how you have been tied up.

Mr. Mineta, as you are coming up, you might want to ask some questions. I will call on you. I will ask one more here.

How did you decide on the figure that you did for the CSTI program? Why not $50 million or $100 million more?

Dr. COLLADAY. The figure arrived at is the final result of building a broad technology initiative that had a number of elements that were scrubbed and screened with a great deal of industry participation and, in fact, from universities and all of the NASA centers and user program offices as well.

We culled that down to strengthen each and every element of the program, and then after several iterations with our industry advisory committees, we packaged the full technology initiative in several increments.

The decision on the CSTI increment was a function of two things: what under constrained budgets we felt we could afford, and the rate at which we could ramp up an increase in technology from the $171 million level that we had in the 1987 budget.

So the decision was made to break it into several increments, the first one being roughly $100 million in fiscal year 1988, and the second one roughly $55 million. We put those two together as two distinct elements and went forward in the administration with that request.

Mr. NELSON. And what was that total request?

Dr. COLLADAY. The total request ended up $90 million for the civil space technology initiative, and the second increment, that we

called Project Pathfinder, was $55 million, and those two together——

Dr. NELSON. All right. Then what did OMB do with your request?

Dr. COLLADAY. The civil space technology initiative was reduced in fiscal year 1988 from $90 million to $70 million, and the decision on Project Pathfinder was deferred, so that program was not approved.

Mr. NELSON. So you went forward with $90 million, not including Pathfinder, and they cut it to what?

Dr. COLLADAY. To $70 million.

Mr. NELSON. To $70 million. And they deferred the $55 million for Pathfinder.

Dr. COLLADAY. That is correct.

Mr. NELSON. It is hard to get it through those boys, isn't it?

Dr. COLLADAY. Yes, it is, except I have to say that on the other hand, I am encouraged by the fact that we have finally turned that trend around and at least we are on a growth pattern.

Mr. NELSON. Any further questions from the committee?

Mr. MINETA. Mr. Chairman, if you would yield for just a minute.

Mr. NELSON. Yes, indeed.

Mr. MINETA. Dr. Colladay, you just said that you are encouraged by that growth pattern, but what is that growth pattern for? I am sorry I didn't get to hear your testimony, but is it for the Air Force launch vehicle? Is part of that money for the Air Force launch vehicle?

Dr. COLLADAY. No, sir, Mr. Mineta, it includes basic propulsion technology that we have historically been involved in throughout the history of the agency and deals with high pressure LOX-hydrogen technology as well as LOX-hydrocarbon.

Now, that LOX-hydrocarbon technology could be in support of future heavy lift launch vehicles because the first stage of those vehicles would likely use LOX-hydrocarbon engines, but it also is required for next generation Shuttle vehicles that would also be, we feel, built around that technology base.

So it is broad based. It isn't targeted at a specific vehicle and is not targeted specifically at any Air Force vehicle, either.

Mr. MINETA. Do we have to go to full-scale development or full-scale testing of that now rather than just laboratory scale as we have been doing?

Dr. COLLADAY. The big uncertainty in LOX-hydrocarbon engines and where research is needed is in ignition and combustion stability. That needs to be done at a fairly large scale. The hardware would not be flight hardware, and it would not necessarily be at full scale, but a large enough scale that we can understand combustion stability. That is research; it is not development or flight hardware in any way. It is not flight-type hardware.

Mr. MINETA. But that is still something that we are not looking at until the mid 1990's, is it not?

Dr. COLLADAY. That is true. That reflects the lead time that propulsion technology has in requiring starting now for the technology that would find its way into a vehicle in 20 years.

Mr. MINETA. Developing and testing full-scale now isn't lead time for mid-1990's.

Dr. COLLADAY. Large scale, not necessarily full scale, and not flight-type hardware.

Mr. MINETA. I thought a lot of this was for full-scale, is it not, Mr. Dawson, in terms of the liquid oxygen hydrocarbon engine? Are we not talking about full-scale testing?

Dr. COLLADAY. Since we do not know what engine will finally be developed, full-scale is synonymous, I guess, with large-scale, but full-scale will be a function of what the final hardware that is developed in a flight engine. We are nowhere near that level of research. We need to deal with large-scale hardware in order to address the combustion stability issues that can't be done in small scale.

Mr. MINETA. I guess I am asking why do we have to develop and test full-scale, large-scale liquid oxygen, hydrocarbon now if it is a mid-1990's item? If we don't need this for a decade, why do we have to do it now?

Dr. COLLADAY. The lead time for technology in propulsion systems is 10 to 20 years. It would be premature to start developing flight hardware 20 years before it was needed. It is not premature to understand things like combustion stability and ignition at high pressure where there is absolutely no data base except back to the F-1 engine experience. There is no data base in high pressure LOX-hydrocarbon combustion stability, and that cannot be done at subscale. You don't understand the scaling effects.

Mr. MINETA. Then let me go back to my original premise. If that is the case and this is a form of technology transfer for the Department of Defense and the Air Force vehicle, why don't we have them fund it over there instead of doing it in NASA?

Dr. COLLADAY. It is technology development for future launch vehicles for this country, and our technology base is a national base to be drawn on by users whether they be eventually DOD or NASA. The level at which we work technology in the research program is far from applications, and as you know, sometimes the ultimate application of technology that comes out of our program, either here or in aeronautics, surprises you when you do an audit trail and in hindsight you look at what the technology path has been.

This is a technology development and a research base for the country, and it is what NASA has historically done. Now, others will draw on that technology base, and it can be the Air Force or it can be NASA, but I don't look at it as technology developed specifically for an Air Force vehicle.

Mr. MINETA. I appreciate that because I am getting more and more concerned about the militarization, frankly, of NASA, and so that is why I keep repeating this, because I want to get at the fact that you are not developing an engine for the Air Force. Let them pack their own weight. Let them do it on their own.

Credibility and the pride that people take in NASA is because of essentially its civil aspects, and there are military aspects. Let DOD carry their weight. When the President talks with pride in his budget about an increase of 9 percent, I believe he uses, for R&D, that's great, but when you look at R&D across the board, 72 percent of that R&D is going into military R&D.

I come from Silicon Valley, and we are getting shortchanged because our engineers are not working on commercial products, they are not working on manufacturing R&D, they are working on military R&D. I think when we look at our trade imbalance, that that is where we are losing out. NASA has always been part of that cutting edge, keeping us on the frontier of technology, and I just don't want to see that edge that we have in the world being undermined by misdirected priorities.

That is why I am not being antagonistic to your being here, because I respect the work that you do. I just want to make sure we are not going down the wrong path.

Dr. COLLADAY. I fully subscribe to that view, Mr. Mineta, and I tried to further emphasize it in choosing the name for this technology initiative. I wanted to emphasize civil, and I fully agree with your comments.

Mr. MINETA. Thank you, Doctor.

Thank you, Mr. Chairman.

Mr. NELSON. You know, what we have here is—I think the figure is actually a $79 million increase as opposed to a $70 million increase for the space research and technology, looking at the budget figures, going from a figure of $171 million in this year to $250 million, and we congratulate you on the increase. The fact is that you had asked for $20 million more.

One of the things that we are constantly struggling with in this committee is trying to convince our colleagues where Mr. Mineta and I have been this morning, in the caucus of the Democrats as they are talking about the realities of the budget and trying to grapple with how do you-all make it come together to get down to the Gramm-Rudman target of $108 billion deficit, and how you can't really do that unless you raise some increased taxes, and how you put all of that together and sell it, since there is no cooperation between the legislative branch and the executive branch on those particular points of driving down that deficit.

It is a tough time, and yet in the midst of these kind of tough fiscal choices, somehow we have got to keep alive the research and development for the future. This is where we have seen a lot of corporations have been short-sighted because they have focused too narrowly on what is their bottom line for this particular quarter to satisfy their stockholders, and they start cheating on putting that money back into research and development, and ultimately down the line they end up on the short side of the equation of who has put the money in and produced the new products that then are the most competitive, the better quality at the lower price.

So I just don't want this country to be in that position, and we have gone through the last decade in which we have cheated ourself on our research and development. As long as these members sitting up at this table have anything to say about it, we are not going to let ourselves do that as we make this next major push of trying to keep this country's technological base vibrant and robust through its space program.

So we are dedicated to that singular purpose, and we need you to get a little noisy every now and then and kick some shins and raise your voice. We need that of the other NASA leadership to get this message across, and when you have to stare down some of those

guys in the Office of Management and Budget, stare them down. We can't run your business, nor should we micromanage your agency. That is not our role. Our role is to appropriate the money, to authorize it, and to set policy and to oversee how you are doing your job.

That would be our message to you today, is get rather vigorous in your pursuit of research and development.

While Mr. Rodney is coming up, why don't you give us a quick overview, Dr. Colladay, just about 2 minutes worth, of the National Aerospace Plane.

Mr. Rodney, come on up and have a seat.

Dr. COLLADAY. As you know, the program is entering its essentially second year of an accelerated technology development phase aimed at a decision point in the late 1989 time frame for collecting all of the technology progress that we have made over this 3-year period in making what I fully expect will be a go-ahead decision to start building the X-30 test vehicle.

It is a technology development program. That test vehicle, X-30, is not an operational vehicle. It is not even a prototype for an operational vehicle. We are trying to in a single test bed develop and demonstrate the technologies that would be required for a single-stage to orbit air breathing vehicle and a hypersonic atmospheric cruise vehicle.

We knew it would be challenging. There are no easy paths through the technology development program, but I am comfortable with the progress that has been made this past year. All of the contractors, eight of them, are making good progress, will be coming up toward the end of this year with a downselect on the airframe configurations and contractors, and the propulsion systems going into the home stretch the next year and a half refining the design leading to that 1989 decision point.

So we have got a joint management team in place. I am generally happy with the way that has taken shape. NASA, Air Force, Navy and DARPA are members in a true joint program. This isn't a coordinated NASA-DOD Program; it is a jointly managed program with elaborate accountability and resource control that we keep our own respective accountability to you, but we manage it together. I am encouraged by the results so far.

Mr. NELSON. So you are on schedule, you are on budget for your three-year determination if the technology will work, and if your conclusion is yes at the end of that three years, then you will go build the prototype, which is the X-30.

Dr. COLLADAY. Yes, that is right, although I shy away from the word "prototype" because it is so often misunderstood that it is a prototype for an operational vehicle. It is a technology test bed. But that is correct.

Mr. NELSON. And that would start about 1989, and that X-30 would be flying, then, and you would determine then what is your time schedule, whether or not you can go to production of the aerospace plane.

Dr. COLLADAY. We should be able to make that decision by the mid-nineties. That is what we have been targeting for, so that you could have an operational vehicle or set of vehicles based on that technology by the turn of the century.

Mr. NELSON. Just for the committee's purposes, although the TAM Subcommittee has been doing the detailed hearings on this, since it would likely be a space vehicle, we will get into this at some future time. We have been in it indirectly overseeing the program, but it would by no means be our only way of access into space into the next century, but you would be looking at other ways, probably a heavy lift vehicle, which we will be getting into more of later on.

Do any other members of the committee have any questions for Dr. Colladay?

[No response.]

Mr. NELSON. Why don't you just remain with us.

Mr. Rodney, if you will share with us.

## STATEMENT OF GEORGE A. RODNEY, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. RODNEY. Mr. Chairman and members of the committee, this is my first formal appearance before a body of Congress.

I would like to start by saying I am fully responsible and accountable for the safety, reliability, maintainability and quality assurance functions of NASA. As such, I report directly to the Administrator, Dr. Fletcher, and have enjoyed his strong support and counsel, and I might say the same for his Deputy, Dale Myers.

I have been working to establish good working relationships with my fellow associate administrators, such as Dr. Colladay, and also the center directors, who are key to our operation. I have been working especially with Admiral Truly and the Manned Flight Center directors.

My prepared statement has a set of goals that we have established, which are really what we are working to achieve. The gist of these is to establish and implement a safety, reliability, maintainability and quality assurance program that is an aggressive contributor to the NASA process, and in the long term will become the national focus for those disciplines.

Second, the other major objective we have is to provide at all times an independent second look assessment as to the health of the operation, whether we are ready to go into a flight or into a significant test operation.

We have been working to establish a better headquarters organization. We have established a new position, the Deputy Associate Administrator for Systems Assurance, who will be responsible for developing an intelligent data system that works problems up through the layers of management, that provides us with an intelligent risk management operation and also has the technical capability to do independent assessments.

We have established, in consonance with the Rogers Commission recommendation, a Space Flight Safety Panel which is headed up by an astronaut, Bryan O'Connor, that provides both myself and Admiral Truly with an independent assessment or insight into operational problems.

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I have also been working very closely with the Aerospace Safety Advisory Panel so that I can take prompt action as a result of the findings of these very able gentlemen.

In our Reliability, Maintainability and Quality Assurance Division, we are emphasizing establishing of policies and procedures to better achieve those functions, and primarily putting emphasis on such things as nondestructive evaluation to support some of our SRM and SSME problems. We are working on software assurance issues very hard, and in the reliability area we are taking a very hard look at the use of numerical analysis or probabilistic risk assessment as an adjunct to the NASA development process.

In the Safety Division, we have enhanced that program substantially both in institutional and systems safety and have started a new program on operational safety headed up by an astronaut, Colonel Fred Gregory.

We have reinstituted the Program Division operation in which we do have colocated persons attached to each of the major program areas. At headquarters we have added some ten civil service people plus three military detailees, and we are heading to doubling that total workforce by 1988.

Our R&D budget is also more than doubling by 1988, in the fiscal 1988 area, and we are doing substantial increase in the support manpower.

I have been spending a lot of time on our center activities, which is the key to our success, both the indigent NASA activity and their major contractors. We have done substantial reorganization and adding fresh blood and additional manpower in all those areas.

We are, incidentally, committed to giving you a formal report on the details of all this activity, I believe, in July.

We have a lot of specific activities going on. In your formal report you have a preliminary short-range plan, two-year plan. Now what I am trying to do is, for the first time, get a detailed program for these disciplines which will help also identify the resource requirements that we need to come forth to you to provide us with those resources.

We are working very diligently in the problem reporting system to develop the techniques and policies to give us a good system which is a foundation for our risk management approach.

In an area such as the SRM redesign, we are actively engaged in all aspects of that redesign, and primarily the test functions and preparation for manufacturing. We have broken down our participation into specific tasks where we can identify the number of NASA people needed to support those tasks, the number of MTI folks and the number of AFPRO people, and I personally am reviewing that in detail with those individuals at least once a month.

We are obviously involved in many other major issues. I can't relate them all today, but things like the SSME, crew escape and landing safety and issues of that type.

All of our goals require people, and we are putting a lot of emphasis on getting new people into the organization and developing a career development program to make the quality and safety disciplines more of a desirable career path.

We have five people, for instance, going into the well-established Army Material Command safety and quality training course, which

is a graduate level, one-year course, and then we will feed them into the program.

Obviously, we have been concentrating on the Shuttle, the manned space program. We are also, however, not totally ignoring our unmanned areas. In fact, they are not unmanned because they are things such as the X-wing program and the propfan, and we are also working the safety aspects of the high cost wind tunnels and things of this nature.*

This, very briefly, is a little bit of a synopsis of a very extensive report we gave you. We have accomplished a fair amount in the last few months. We have a long, long way to go; however, I fully expect to have a very viable program that will ensure that we have a successful startup of the Shuttle program.

[The prepared statement of Mr. Rodney follows:]

* See appendix, p. 1200.

STATEMENT OF
MR. GEORGE A. RODNEY
ASSOCIATE ADMINISTRATOR FOR SAFETY, RELIABILITY,
MAINTAINABILITY AND QUALITY ASSURANCE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
BEFORE THE
SUBCOMMITTEE ON SCIENCE SPACE AND APPLICATIONS
COMMITTEE ON SCIENCE SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

Mr. Chairman and distinguished members of the Committee:

I am pleased to appear before you today to report on the progress we have made in NASA's Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) Program. I will briefly summarize our efforts and progress and will then amplify on areas I believe are of special interest to you and the Committee.

First, I believe it extremely important to have explicit goals stated to provide a focus for our efforts and to measure our progress. The goals of NASA's new SRM&QA program are as follows:

- Establish the SRM&QA function as an aggressive contributor and as a check and balance to the overall NASA operation, and to become the national focus for SRM&QA functions and technologies.

- Develop a system for the identification of problems and their subsequent analysis, corrective action, and communication up through all levels of management.

- Provide a second-look assessment of the entire NASA development and operating process, design, development, manufacturing, procurement, test and operation.

- Develop and ensure implementation of firmly-defined policies and procedures for SRM&QA on a uniform basis throughout the agency.

- Develop a SRM&QA workforce that is manned with quality people who are properly trained and equipped, and who are dedicated to superior performance and the pursuit of excellence; and to provide the leadership in implementing this goal to the entire NASA/industry workforce.

- Provide at all times, oversight directed toward 100 percent operational success in a safe manner.

In addition to the establishment of my position as Associate Administrator for SRM&QA at NASA Headquarters, the program has been consolidated and expanded. This has provided the authority to examine all aspects of NASA's SRM&QA program enabling us to identify areas where attention must be focused and to draw on our best talents inside and outside NASA to affect solutions. Dr. Fletcher's strong support and the close interface we have established with the Centers provides a solid foundation from which to proceed as an aggressive and constructive contributor to NASA activities and to provide NASA management with an independent assessment of the technical status and safety of these activities.

The increased FY 1988 SRM&QA budget request is planned in part, to revitalize NASA's basic safety program and to create an agencywide systems assurance function which will provide a capability for problem reporting, corrective action and trends analysis. The extensive data base provided by this system will be used for design, flight, and test reviews and will be accessible by NASA and our contractors. The trend analysis capability will provide early and more complete illumination of problems for senior management.

We have also established major initiatives in risk management policies, advanced non-destructive evaluation techniques, Failure Modes and Effects Analysis, Critical Items List, Hazards Analysis, and flight and ground operational safety. Other initiatives now underway include enhancement of contract provisions and incentive-award-fee criteria for SRM&QA and consolidation of SRM&QA functions at various NASA centers.

I would now like to expand on our efforts in several areas. The considerable responsibility and authority of this function requires the appropriate SRM&QA organizational structure at the Headquarters and within the Centers. Within the Headquarters, I am supported by three line divisions, a Space Safety Panel, a support staff and a Deputy Associate Administrator for Systems Assurance.

The Reliability, Maintainability and Quality Assurance and the Safety Divisions are line organizations which form the core of the organizational elements of the office. These two divisions establish, document, and maintain the SRM&QA policies, plans, procedures and standards for the Agency. As a part of the Safety Division, an Operations Safety Branch, headed by an astronaut, has been established with specific emphasis on flight safety. The Program Assurance Division establishes an active role for SRM&QA at the Headquarters level in the various NASA programs (e.g., STS, Space Telescope, etc.). Individuals from my office have been assigned to work with the program offices on a daily basis on their major projects. This will assure that I can maintain visibility into the major programs and enable me to influence the direction of their SRM&QA programs.

The Deputy Associate Administrator for Systems Assurance ensures that adequate communication of problems and trends exists and that a strong system of independent checks and balances is established at the Headquarters and the Centers. The Space Flight Safety Panel, chaired by an astronaut, and reporting to me, will provide an independent assessment of mission preparation and operations. The Headquarters SRM&QA staff is planned to increase to approximately 60 civil service employees in FY 1988 to cope with the increase in functions and oversight.

We have removed the R&QA functions from engineering directors at both the Marshall Space Flight Center (MSFC) and the Kennedy Space Center (KSC) and consolidated them under a director of SRM&QA reporting to their respective Center Directors. At Johnson Space Center (JSC), we have increased the Level II Space Transportation System (STS) Program office SRM&QA capability to support integration activities across the program. Additional support contractor SRM&QA manpower has been obtained at both NASA Headquarters and STS Centers. To ensure a cohesive effort, this Headquarters and all NASA Center SRM&QA Directors have been tasked to develop a short-range plan (two year outlook), and long-range plan (five year outlook), and a strategic plan (ten year outlook). These plans will be used to develop a more cohesive and interdependent SRM&QA program across the Agency and contractors and permit meaningful input to the NASA budget process.

The Headquarters SRM&QA budget request is planned to increase to $16.2 million for FY 1988, about a 80 percent increase over the 1987 budget. The Headquarters budget is focused on areas that affect NASA-wide SRM&QA functions, and we allocate funds to Centers and other organizations to support Headquarters in these activities. The FY 1988 Headquarters SRM&QA budget request is allocated into the areas of Reliability, Maintainability and Quality Assurance ($6.2M), Technical Assessment Program ($4.0M), Safety Program ($4.0M), and Program Practices ($1.9M).

NASA's overall SRM&QA resource requirements and authorizations have not been visible in our management tools in the past. This has certainly hampered my efforts to understand and match requirements with authorization. I am hesitant to discuss details on manpower data at present, because I know there are inconsistencies and inaccuracies in the data. However, my best projections at present are that the NASA civil servant SRM&QA community will probably increase by about 14 percent in 1987 and by over 20 percent in 1988 from a FY 1986 baseline.

I have established formal reporting requirements on SRM&QA manpower and budget data that, in the future, will provide more accurate and consistent data and enable me to make rational decisions on requirements versus authorizations. I hope to be in a position to give you more accurate data by July 1, 1987.

The need for an effective information system supporting the decision making process is a requirement for an effective SRM&QA function. Major initiatives are underway to establish NASA Headquarters requirements for Problem Reporting, Corrective Action and Trend Analysis (PCT). This system is being developed to provide the necessary information to support independent technical assessments and trends by the SRM&QA offices and to support normal program requirements. Screening criteria and techniques to ensure that significant problems are elevated to the proper management level are also being developed. A NASA Management Instruction (NMI) on PCT is near completion. NASA Handbooks on problem reporting and corrective action, trend analysis requirements and techniques are in development. We are also currently in the process of establishing and networking a large data base system across the Agency to support our PCT efforts.

Risk management is another major initiative underway. While risk management is not new to NASA, our effort in this area is to develop and implement a standardized risk management methodology. While risks exist with all programs, the key to its successful management is to understand and control the uncertainties in a formal and cohesive fashion in our decision making process. We have developed policy and guidance in a NASA management instruction the essence of which is more centralized coordination and review of risk management practices, applying the policy to all major new programs and the STS, and requiring program managers of existing programs to assess applicability. While recognizing that performance, cost and schedule all have influences on the risk equation, my office will focus only on those elements related to safety and mission success considerations. Studies are in progress to determine the risk assessment techniques, including a consideration of probability risk assessment that are appropriate to NASA functions and which could augment the existing Failure Modes and Effect Analysis (FEMA)/Critical Item List (CIL)/Hazards Analysis (HA) techniques.

The SRM&QA personnel at Headquarters and the centers are integrally involved in the FEMA/CIL/HA review process and other recertification efforts underway. These efforts assess the data available from tests and analysis leading to certification of safety critical items. All applicable data, both generic and explicit, quantitative and qualitative, will be used in continuing flight certification and risk assessment activities.

Regarding the SRM redesign effort, there are a number of actions taken or underway. First, we have complete access to all redesign activities and participate in the effort. I personally receive monthly SRM&QA briefings on progress and problems. We have instituted detailed planning of associated SRM&QA activities. This provides detailed visibility of manpower requirements, provides a mechanism to track progress and ensures SRM&QA activities are coordinated with overall program

requirements. This also ensures that there are no oversights in SRM&QA activities and coverage. MSFC has augmented coverage with 25 people at MSFC and with 5 MSFC personnel stationed at Morton Thiokol (MTI). AFPRO operations at MTI has also been augmented by creation of a Quality Engineering Group and a increase in total staff from 38 to 49. Reorganization of SRM&QA at MTI has been centralized under a single point of authority reporting directly to division vice president and general manager. The MTI SR&QA capability is being increased from 294 to 343 as of February 1, 1987, of which 242 are devoted to the redesign effort. By the end of March 1987, the MTI SR&QA strength will increase to 442.

A detailed review of critical processes by MSFC, MTI and AFPRO has been initiated with a reassessment of all critical vendors in process. Establishment of non-destructive evaluation (NDE) as a major goal has been accomplished and a reassessment of NDE requirements and techniques is in progress. Specific SR&QA concerns for each element of the redesign has been identified and are being tracked. The quality and reliability of SRM's are highly process dependent and major emphasis is being placed on process discipline. Nozzle manufacture and inspection complexity has been recognized.

Several initiatives in the areas of safety are being implemented. An Enhanced Safety Program is being developed to promote a centralized proactive safety program. We have established a new role involving Headquarters safety review and approval responsibility, and have generated a conceptual plan for a preventive safety program. The conceptual plan sets forth general goals and objectives, defines a recommended organizational structure and delineates resource requirements guidelines. The Space Flight Safety Panel, I mentioned earlier, is established to provide an independent communication link to me on matters pertaining to space flight programs involving flight crews. We have established a Safety Risk Assessment Ad Hoc Committee to review center and contractor procedures and provide an independent review and assessment of STS safety management systems. This will provide input for policy making and guideline development. In addition, I am participating in the Aerospace Safety Advisory Panel activities to take maximum advantage of their efforts in assuring safe flight operations.

Key to implementation of the Enhanced Safety Program is a comprehensive review of safety documentation and revision or development where needed of safety policy, procedures, practices, regulations, manuals, handbooks and other documentation. Also a key initiative is the development of the NASA Safety Information System (NSIS) which will be integrated with the overall NASA problem reporting, corrective action, and trend analysis system. The NSIS will provide a complete and readily accessible, centralized source of agencywide information for use in preventing hazards and mishaps.

In addition to the NSIS, a backup off-line safety reporting system is being developed along the lines of the FAA "near miss" system. The objective is to provide an independent mechanism for supplementing the more formal safety reporting structure. It will provide an easy to use mechanism for reporting safety concerns directly to Headquarters NASA and will offer confidentiality or anonymity if desired.

Adequate visibility into the mission planning process is essential. This Headquarters and Center SRM&QA offices are an integral part of the process. We are and will continue to participate in all reviews related to mission preparation and examine related reports and schedules. In addition to on-site monitoring and audits, we are in the process of establishing management performance indicators to assist in the evaluation of schedule pressures. The objective is not only to provide visibility but to look for the sometimes intangible effects of slips or changes on safety in critical risk areas and to take corrective action. This will place me in a position to determine if schedule pressures or other factors are adversely affecting safety.

While much of our initial efforts have focused on the STS, we are expanding the scope to include other NASA programs such as the Space Station. We are conducting an independent review of the Space Station SRM&QA program, its procedures, and organizational functions and relationships. We are developing an implementation plan based on lessons learned from STS/51-L. Part of this effort is development of the Space Station problem reporting and corrective action system in conjunction with the STS PRACA system. Another element is development of an implementation plan for SRM&QA oversight and interaction with the Space Station foreign partners. By participating in early stages of the program, we are well positioned to ensure that SRM&QA policies and processes become an integral part of the effort.

People are the key ingredient in the success of these initiatives and effective implementation of NASA SRM&QA policies and practices. The retention and enhancement of qualified SRM&QA personnel is crucial and requires a career program that recognizes excellence and promotes the career opportunities in NASA SRM&QA system.

We are also currently negotiating to participate in an established DoD institution that offers intern training programs in the SRM&QA disciplines -- The Army Materiel Command's School of Engineering and Logistics, Career Intern Program. We plan to have people in the 1987 class.

I have mentioned a few of the initiatives and efforts we have underway. There is much that remains to be accomplished but I am confident that we are establishing a solid structure for the current and future strength of SRM&QA in NASA. I have and will continue to personally visit and interface with the NASA center's

senior managers and officers of NASA contractors to ensure that every opportunity exists to communicate the challenges and opportunities. In a more formal fashion, we have established an audit program under the Deputy AA for Systems Assurance. Audit teams will be composed of individuals from NASA, other Federal Agencies and industry with the experience, skills, and charter to ensure that comprehensive institutional and project inspections and audits are performed.

I have enclosed a copy of my preliminary, short-range program plan for your information. There are deficiencies in the document that we are still working to resolve, but I believe it is important that you have visibility into where we plan to take NASA's SRM&QA program over the next two years. I would welcome any suggestions you or your staff may have with respect to this plan.

Mr. Chairman and distinguished members of the Committee, in closing, I would like to state that I recognize the crucial responsibilities delegated to me in the NASA SRM&QA function. I appreciate this opportunity to present a synopsis of the efforts we have underway and planned to meet those responsibilities. Let me assure you that we do have an active and aggressive SRM&QA program, and I will not hesitate to exercise my independent authority where appropriate.

Mr. Chairman, this completes my prepared statement. I would be pleased to respond to questions you and other members of the Committee may have. Thank you.

PRELIMINARY
NASA HEADQUARTERS
SAFETY, RELIABILITY, MAINTAINABILITY,
AND QUALITY ASSURANCE
SHORT RANGE PROGRAM PLAN

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|---|---|---|---|
| Prepared by<br>Director,<br>Data Systems &<br>Trend Analysis | Date | Approved by<br>Associate Administrator<br>for Safety, Reliability,<br>Maintainability and<br>Quality Assurance | Date |

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## PREFACE

In response to the June 1986 recommendations of the Presidential Commission on the Space Shuttle Challenger Accident, NASA has established an Office of Safety, Reliability, Maintainability and Quality Assurance (SRM&QA). By removing SRM&QA functions from engineering organizations and consolidating them under a Director of SRM&QA, the new organization will effectively centralize safety, reliability, maintainability, and quality assurance and will ensure consistent application of SRM&QA standards by all organizational elements. The SRM&QA office will function as an aggressive contributor to agency policy and act as check and balance to overall NASA operations.

The Associate Administrator (AA) for SRM&QA will establish a short range program plan (2-year), long range program plan (5-year), and a strategic plan (10-year).

This document constitutes the preliminary short range program plan for the office of the AA for SRM&QA. The enclosed milestone schedule for the plan specifies the specific tasks and target dates for required action. The plan is classified as preliminary because several major additions relative to review of major program activities are expected within a few weeks, and other "to be determined" areas remain to be completed.

Each NASA Center and JPL are required via this plan to develop local SRM&QA plans in similar format and consistent with the document. Such plans will be forwarded to the office for review within 45 days from the approval date of this plan.

The plan will continue to be refined and amplified as requirements change and we gain experience.

## INTRODUCTION

The goals of the SRM&QA effort are as follows:

- Establish the SRM&QA function as an aggressive contributor and as a check and balance to the overall NASA operation, and to become the national focus for SRM&QA functions and technologies.

- Develop a system for the identification of problems and their subsequent analyses, corrective action, and communication up through all levels of management.

- Provide a second-look assessment of the entire NASA development and operating process - design, development, manufacturing, procurement, test and operations.

- Develop and ensure implementation of firmly-defined policies and procedures for SRM&QA on a uniform basis throughout the agency.

- Develop an SRM&QA workforce that is manned with quality people who are properly trained and equipped, and who are dedicated to superior performance and the pursuit of excellence; and to provide the leadership in implementing this goal to the entire NASA/industry workforce.

- Provide at all time, oversight directed towards 100 percent operational success in a safe manner.

The SRM&QA organizations will play an important role in NASA's planning and development process of the future. The

short range program plan is intended to guide SRM&QA in its initial efforts. A breakdown is provided of planned SRM&QA activities and projected milestones. A brief overview of the significant elements of each of the five major sections of this draft is provided. The five major sections are:

A. Organization
B. Resources
C. Policies and Guidance
D. Implementation and Procedures
E. Program Review/Evaluation

These sections have a corresponding milestone schedule attached for the plan tasks.

## A. ORGANIZATION

The organizational structure of an agency is a significant factor in determining the success and effectiveness of its programs. Quick and responsive action has been taken by the establishment of NASA's Office of Safety, Reliability, Maintainability and Quality Assurance (SRM&QA). Within three months following the release of the Rogers Commission's recommendations, Mr. George Rodney was appointed to the new position of Associate Administrator (AA) for SRM&QA. His organizational role and responsibilities and the establishment of this new organization was approved by NASA Management Instruction NMI 1103.9A, dated December 15, 1986.

The organizational approach taken by this new office has effectively defined its various responsibilities. The Reliability, Maintainability and Quality Assurance Division and the Safety Division and Program Division are line organizations which form the core organizational elements of the office. The RMQA & Safety divisions establish, document, and maintain the SRM&QA policies, plans, procedures and standards for the agency. The Program Assurance Division will provide the necessary day-to-day SRM&QA support to the program offices and report routinely to the AA for SRM&QA on the health of those programs. The Deputy AA for Systems Assurance ensures that adequate communication of problems/trends exists and that a strong system of independent checks and balances is established at Headquarters and the centers. The Space Flight Safety Panel, to be chaired by an astronaut, will provide an independent assessment of mission preparation and operations. Other functional responsibilities include data systems and trend analysis, systems assessment, safety, reliability and quality assurance, software management and assurance, engineering standards and electronic parts standards.

A second measure being taken in the establishment of this office is the documentation of program plans and future efforts. All NASA Center SRM&QA Directors have been tasked to develop a short range plan (two year outlook), a long range plan (five year outlook), and a strategic plan (ten year outlook). These plans will be used to document goals, resource requirements, and interface requirements needed to assure the establishment and maintenance of an effective NASA SRM&QA program.

As a direct result of efforts by the office of the AA for SRM&QA, changes have been made in the SRM&QA organizations at certain Centers and contractors. Additional changes will be made as reviews continue.

## B. RESOURCES

One of the critical issues facing the SRM&QA organization today is that of resource requirements. These requirements must be defined in terms of budget and manpower. Several initiatives are being taken within these two areas to define requirements and understand authorizations.

Preliminary planning has begun to upgrade the skills of the NASA SRM&QA profession and develop a career progression approach and intern program to attract high quality people to the profession. NASA is currently reviewing the numbers and qualifications of key staff in technical and management positions in order to determine the need for additional training or recruitment of individuals. It is clear, however, that additional personnel are needed to maintain the proper degree of oversight of contractor personnel and internal coordination.

A preliminary manpower requirements analysis has been conducted on NASA's total SRM&QA personnel assets including civil service, SRM&QA support contractors, and DoD DCAS and AFPRO. This provides a rough estimate of baseline and projections of SRM&QA requirements through FY88, but does not provide the accuracy and visibility required. Centers will provide a SRM&QA manpower status report monthly to this office as well as a quarterly report on requirements and authorizations. These reports will provide an early lead on any change in needs and will highlight any problems in acquiring personnel enabling appropriate action to be taken. Centers will be expected to develop similar visibility into their major contractor SRM&QA programs. This will be monitored periodically by the AA for SRM&QA to assure viable programs at our major contractor activities.

We will develop insight into requirements and authorization for special projects in the SRM&QA area in the R&D, R&PM, and SFCDC appropriations.

All Center and HQS SRM&QA manpower & budget analysis are expected to be completed with sufficient lead time to allow the AA for SRM&QA to formulate positions no later than June 1, 1987.

## C. POLICIES AND GUIDANCE

One of the primary objectives of the Office of Safety, Reliability, Maintainability and Quality Assurance is the establishment of firmly defined policies and procedures for uniform SRM&QA throughout the agency. Several areas are being particularly emphasized in this effort: systems assurance, safety, problem analysis, systems assessment, software management and assurance, non-destructive evaluation and a NASA wide electronic parts standardization program. Each of these areas is integrally tied to NASA's overall risk management policy.

The basic concept of the NASA risk management program is to maximize safety and reliability within program constraints and operational limitations. New initiatives by SRM&QA to develop improved risk management approaches have been taken to establish a stronger, more centralized risk management approach. Specific risk management directives are being developed on such issues as trend analysis requirements and techniques. Risk assessment methodology for ranking problems in order of significance are also in development.

A policy decision to undertake the development of nondestructive methods for inspection, assessment and control of hardware is crucial to cost effective risk analysis. A center of excellence in non-destructive evaluation (NDE) has been established to develop NDE tools. The ultimate goal is to develop one new NDE method per year for field use. An additional policy is to develop and strengthen workmanship standards. This is a continuous effort to develop and upgrade standards, handbooks, and directives and control procedures.

Independent institutional and technical assessments and audits of Center SRM&QA activities as well as systems and programs are a key part of NASA risk management policy. Such assessments and audits will provide HQ NASA, Center and programs with a continuous independent review of their status unbiased by the pressures of schedules and cost. Procedures and check list for HQS, Center, and contractor audits will be developed as well as follow-on lessons learned packages.

Closely related to SRM&QA's risk management policy is the Problem Reporting, Corrective Action, and Trends Analysis (PCT) concept. This concept is supported by the Systems Assurance Division of SRM&QA, which will focus on analysis of problems and provide an independent assessment of both problem trends and individual critical issues. An intercenter Problem Reporting and Corrective Action (PRACA) information system and a Program Compliance Assessment Status System is being developed to support PCT policies.

The establishment of the NASA Safety Information System (NSIS) and a comprehensive review and upgrade of directives, handbooks, guidelines and manuals will strengthen NASA's safety program. The NSIS will be an integral part of the agency PCT system and will provide a complete and readily accessible centralized source of agency-wide information. It will provide information for tracking and evaluating known safety concerns and for detecting and identifying safety concerns not previously known. The NSIS will respond to a wide range of specific and general requests from the Safety Division, field installations, programs and contractors. The NSIS will support risk, risk-benefit, and risk-cost-benefit analysis implemented in the NASA risk management program.

The capability of on orbit repair/maintenance, the "Lessons Learned" on Shuttle, and the advent of Space Station, dictate

that a clear policy on maintainability, and its relationship to reliability and systems engineering must be established. To accomplish this objective, the policy governing Reliability Requirements for NASA programs has been revised. Maintainability is a new discipline within the Agency. A policy document regarding the engineering and analytical requirements for maintainability will be published in 1987. Recognizing the need to improve the skills in the maintainability discipline within NASA, a task has been undertaken in the Office to develop a preferred maintainability methodology; supplemented by in-house training courses on the subject.

The NASA Software Management and Assurance Program is an ongoing activity within the Reliability, Maintainability and Quality Assurance Division of the Office of Safety, Reliability, Maintainability, and Quality Assurance. Most NASA software is acquired through development contracts. The NASA Software Management and Assurance Program has defined a standard software acquisition life cycle management methodology. A complete set of software documentation standards has also been created for use as data item descriptions on NASA software development contracts. With these two essential prerequisites (methodology and documentation standards) are available, the Software Management and Assurance Program is formulating policy and guidance required to initiate an effective NASA-wide automated system's assurance program.

Guidebooks and training courses for software acquisition management and product assurance functions have been developed and are currently being enhanced. These courses and the associated guidebooks are based on the established acquisition management methodology and address the use of the established documentation standards. The activity formulating the automated system's assurance policy and guidance is providing the training activity with the information necessary to ensure

that policy training is available when it is approved and implemented.

In summary, the policies and guidance function of SRM&QA requires the support of documentation. In light of this, a review and update is being conducted of many manuals, directives, and instructions addressing the areas of SRM&QA. In particular, a wide variety of publications pertaining to the topic of safety and quality assurance are being re-evaluated and revised as necessary. Major new policies are also in development.

## D. IMPLEMENTATION AND PROCEDURES

The policies and guidelines developed by SRM&QA are only successful when supported by evidence attesting to their effectiveness. The milestone schedule for Implementation and Procedures list the specific action tasks called for by the short range program plan. The many reviews, reassessments, reports and other activities are necessary to ascertain status, progress and problem areas. This is also necessary to verify implementation of policies, directives and guidelines and to determine any areas where new or modifications to guidance are necessary. Such varied issues as in-flight anomalies, overtime levels, and cannibalization of spares will be documented on a regular basis to assure compliance with agency guidelines.

A major element of the short range program plan is the development of an effective Significant Problem Report (SPR) to assure adequate communication and assessment of problems and trends in the agency. Initial efforts are devoted to the STS, Space Station, and associated payloads, but will be eventually expanded to other areas. Although screening criteria are still in development it is anticipated that the periodic SPR will be based on a portion of the following major data sources:

1) All "accepted risk" and selected "controlled" hazard reports.

2) All CR1, CR1R, CR1S OMRSD waivers and selected CR2, CR2R waivers.

3) All CR1 OMRSD RCN's and selected CR1R, CR2, and CR2R OMRSD RCN's.

4) All CIL waivers on CR1, CR1R, CR1S, and CR2 and selected CR2R items.

5) All payload critical and catastrophic waivers and selected critical and catastrophic hazard reports.

6) Selected ground/industrial concerns affecting criticality hardware or software.

7) All Type A, B, and C STS related mishap reports.

8) All CR1 and CR1R related In-Flight Anomalies.

9) All SRM&QA items on the Launch Constraints List.

10) Any waivers to the Launch Commit Criteria.

11) Any waivers to the flight rules.

12) Selected Problem Reports (PR), failures and unsatisfactory conditions associated with CR1, CR1R, and CR1S explanations and closeouts; unexplained anomaly explanations; and crew emergency equipment explanations and closeouts.

13) Selected MR/DR indicators prior to Government acceptance associated with CR1 and CR1R potential failure modes, factor of safety at maximum limit, and repairs having a major schedule impact at the launch site.

The data elements listed above will most likely be evaluated against a risk assessment model that will highlight significant problems and minimize the forwarding of data considered to be of minimal risk. The risk assessment model will be relativistic in nature and will incorporate severity and

likelihood elements as well as other risk indices. Probability studies have also been initiated on the MPS and APU systems to determine if those techniques can enhance our risk assessment and decision making process.

People are a key ingredient for successful implementation of NASA policies and practices. The AA for SRM&QA will advise Center Directors on Center SRM&QA Directors performance plans to ensure that they incorporate adequate performance criteria, and will make input to the Center and AA performance plans. The retention and enhancement of qualified SRM&QA personnel is crucial and requires a career program that recognizes and promotes the career opportunities of personnel in SRM&QA. The establishment of a SRM&QA intern program and Career Development Program, to attract and retain capable individuals is also being developed. The AA for SRM&QA will hold regular meetings with center SRM&QA directors to personally ascertain the progress and challenges in SRM&QA, to improve coordination and to receive timely updates.

A review of the STS configuration management system is also a procedural initiative planned by SRM&QA, designed to provide oversight of changes in hardware, software, and documentation that affect sound risk management decisions. Any deficiencies in the system will be highlighted and recommendations developed to eliminate those deficiencies. After a review of the STS, an overall review of Agency configuration management will be conducted.

The SRM&QA personnel at Headquarters and Center are integrally involved in the Failure Mode and Effects/Critical Items List/Hazards Analysis review process and other recertification efforts underway. The Failure Modes and Effects Analysis (FMEA) and the Critical Items List (CIL) are two means of review and documentation. These reports assess the test data

and analysis leading to the certification of safety critical items. All applicable data, both generic and explicit, quantitative and qualitative, will be used in continuing flight certification and risk assessment activities. In conjunction, NASA will reassess all in-flight anomolies to assure that corrective actions or safe-guards are in place, or planned, for the safety of mission critical hardware prior to resuming Space Shuttle flights. Particular emphasis is being placed on the solid rocket booster redesign and evaluation of the space shuttle's main engines in which this office is an active participant.

This office will play an integral role along with Center SRM&QA officers in the mission planning process. While Center offices will be involved in the day-to-day detailed planning process, this office will establish management indicators to monitor the planning process to ensure that such areas as schedule, overtime rates, cannibalization practices, mandatory inspections and reviews do not adversely effect safety. This office will be alert for any trends or indications of slips as highlighting potential problem areas and schedule pressures.

Several initiatives in the area of safety are being implemented. A conceptual plan for an overall Enhanced Safety Program has been developed as well as specific programs focusing on landing safety and crew safety. A STS Safety Risk Assessment Ad Hoc Committee has been established to review center and contractor risk assessment procedures which will provide input for policy documents. Key to implementation of the Enhanced Safety Program is the development of the NASA Safety Information System (NSIS). The NSIS will provide a complete and readily accessible, centralized source of agency-wide information for use in preventing hazards and mishaps and in identifying risks. This effort is currently in the requirements definition phase. A backup off-line safety notification system is being implemented. This system will provide the

capability for NASA and Contractor personnel to notify NASA SRM&QA offices of problems that potentially may result in loss of life, injury, loss of mission capability or property damage. This system will enable individuals when (in the individuals opinion) normal management actions are inadequate in terms of timeliness or degree of response in reacting to the problem. The off-line system will offer confidentiality or anonymity according to the desire of the individual. The intention is to have the off-line reporting system function similar to the FAA's near-miss reporting systems.

It is essential for the successful implementation of the guidance and execution of these tasks for the close coordination and cooperation with NASA contractors to be maintained. The NASA Excellence Award for Quality and Productivity recognizes outstanding contractors and subcontractors who have demonstrated continuing improvement in hardware and/or service performance. We believe the policy of recognizing superior performance will motivate contractors to seek excellence. We will also participate in award fee determinations as well as review contractual provisions for appropriate clauses and incentives to focus contractor attention and efforts in SRM&QA.

Non-destructive evaluation processes being developed will enhance cost-effective methods for inspection, assessment and control of hardware and manufacturing processes. The results of these efforts will result in the means for better ensuring quality and integrity of products that have traditionally been difficult to ascertain or required costly testing to destruction.

Via the Preliminary Short Range Program Plan the SRM&QA Managers for Codes M, S, R, and E/T will develop specific

SRM&QA milestones for each major program under their purview. Those milestones are to be furnished to the Director of Data Systems and Trend Analysis within 20 calendar days from approval of this plan. The milestones will address as a minimum your evaluation of each of the following for each major program:

1) Initial and periodic evaluation of the major program plans (i.e., System Safety Program Plan, Reliability Plan, Quality Plan, Maintainability Plan and Risk Management Program Plan).

2) A formal risk assessment before each major program design review and Operational Readiness Review.

3) Comments on SRM&QA trade studies for any new programs.

4) Periodic review of locally granted SRM&QA waivers.

5) A sampling review program of hazards analyses, maintainability studies, and Failure Modes & Effects Analysis.

6) An active review of the Critical Items List, or other counterpart documents.

7) Parts/Materials program review.

8) Periodic review of award/incentive fee criteria.

9) Review of certification/acceptance test plans.

10) SRM&QA training/certification programs.

11) A periodic assessment of design margin concerns.

12) A periodic assessment of the NDE program.

13) Periodic assessments of the problem reporting, corrective action, and trend analysis program.

14) Periodic assessment of operational procedures and Mandatory Inspection Points (MPI), and Critical Process procedures.

15) Assessments of the motivation/awareness program.

16) GSE SRM&QA plans reviews.

17) Periodic assessment of SRM&QA resources available to programs.

18) A formal quarterly briefing to me on progress under your purview.

For the most part, I will expect you to make formal, written assessments of the above areas.

The previous plan action items are focused heavily on the STS, however, we recognize the need to extend our efforts along similar lines to other NASA programs. This includes STS payload programs (Code E), aerodynamic programs (Code R) and the space station (Code S). Particular attention is being given to applying the lessons learned from STS/51-L to the space station and payload programs in conducting assessments and reviews.

The effort called for in executing these tasks is extensive. As experience and data is accumulated through the many reviews and assessment activities indicated on the milestone charts, it is expected that certain areas will require increased focus while others will require less. The many tasks in the short range plan will provide the data base and knowledge necessary to provide refined emphasis and focus.

## E. PROGRAM REVIEW/EVALUATION

Formal audits and evaluation of Centers, contractors, programs, projects and special problem areas are planned. The audit teams under the control of the Deputy AA for Systems Assurance will be composed of individuals from NASA, DoD, other Federal agencies, and industry, with the experience and skills to ensure that a thorough, comprehensive inspection and audit is performed. Audit results will be reported and briefed to the Associate Administrator (AA) for SRM&QA and the Center Director. Selected areas will be briefed to the Administrator and selected Associate Administrators. A corrective action response will be required from institutions, contractors and programs on all unsatisfactory or marginal findings. Critical problem areas will be formally entered into the NASA PCT system to assure proper corrective action.

The intent of these audits is to assure compliance with established policies/guidance, identify any major problems, assist other organizations with tneir SRM&QA programs, and cross-fertilize good SRM&QA characteristics among organizations.



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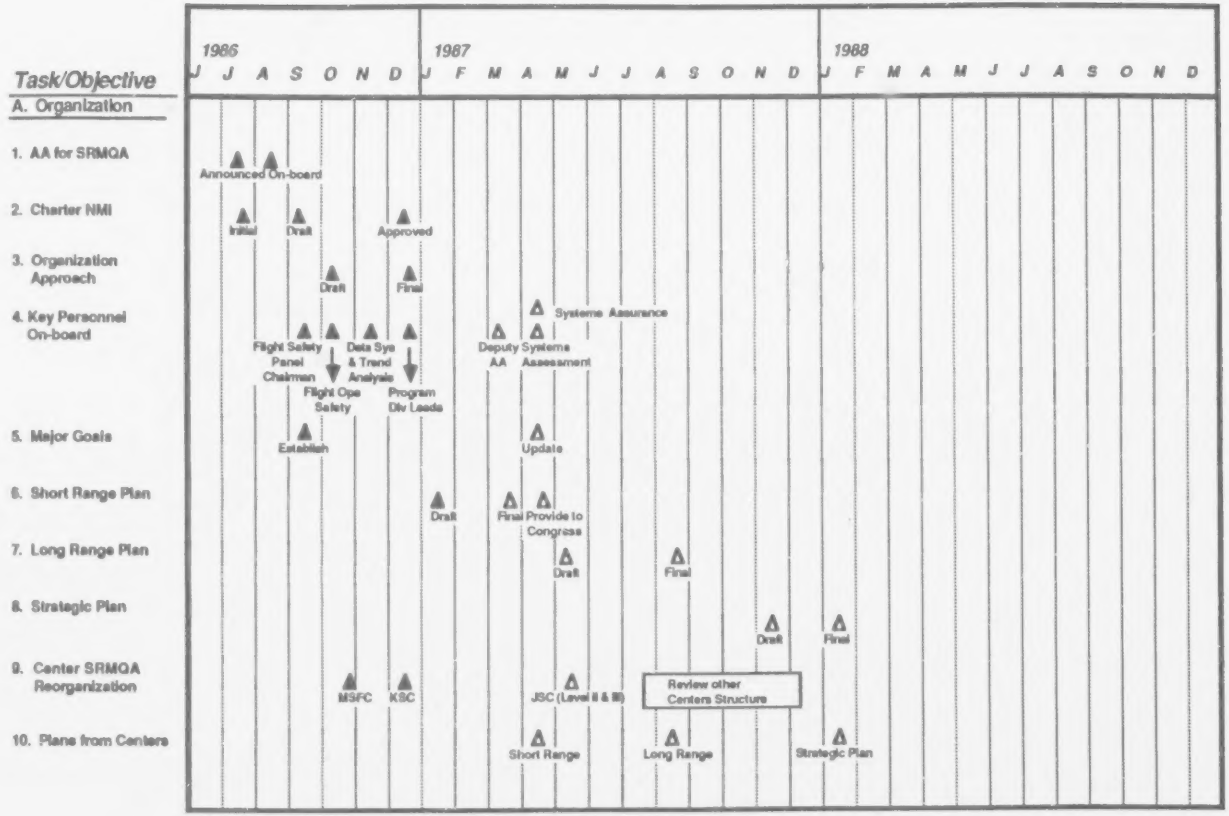
## NASA HEADQUARTERS SRMQA SHORT RANGE PROGRAM PLAN



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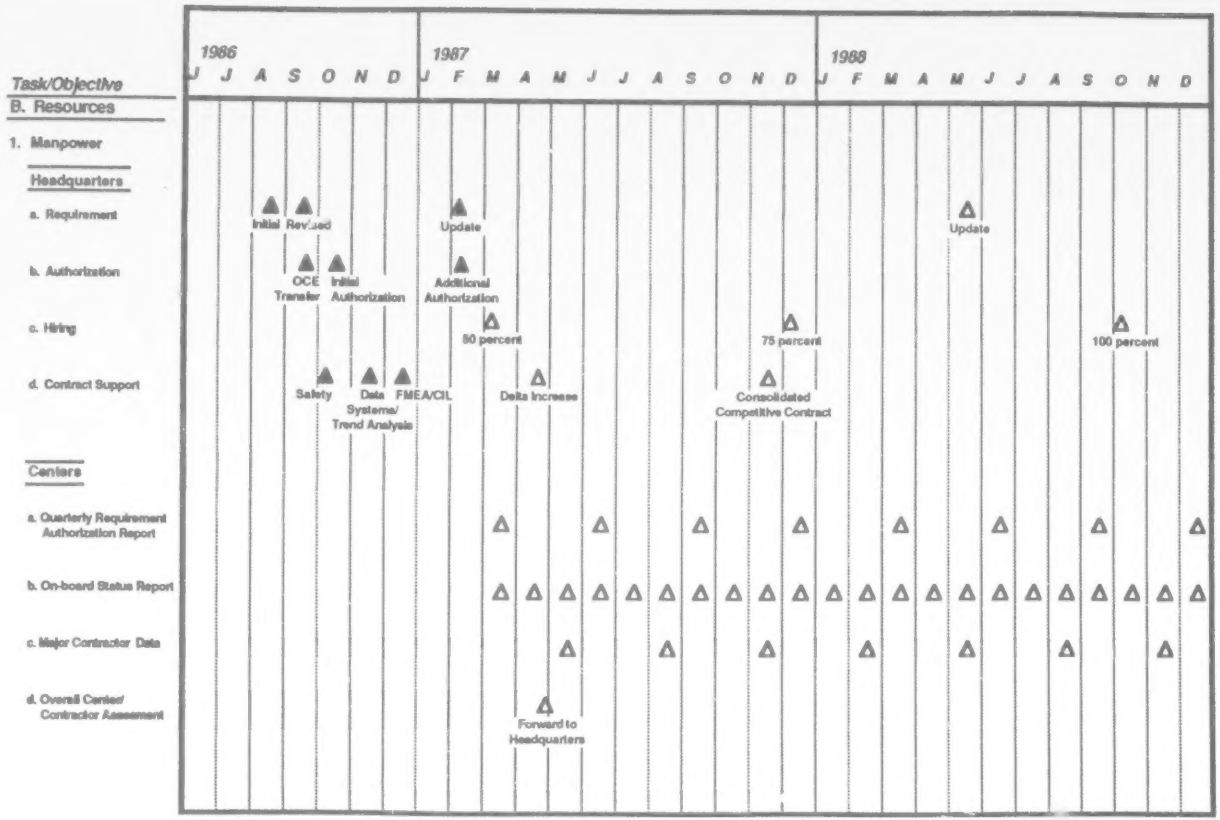

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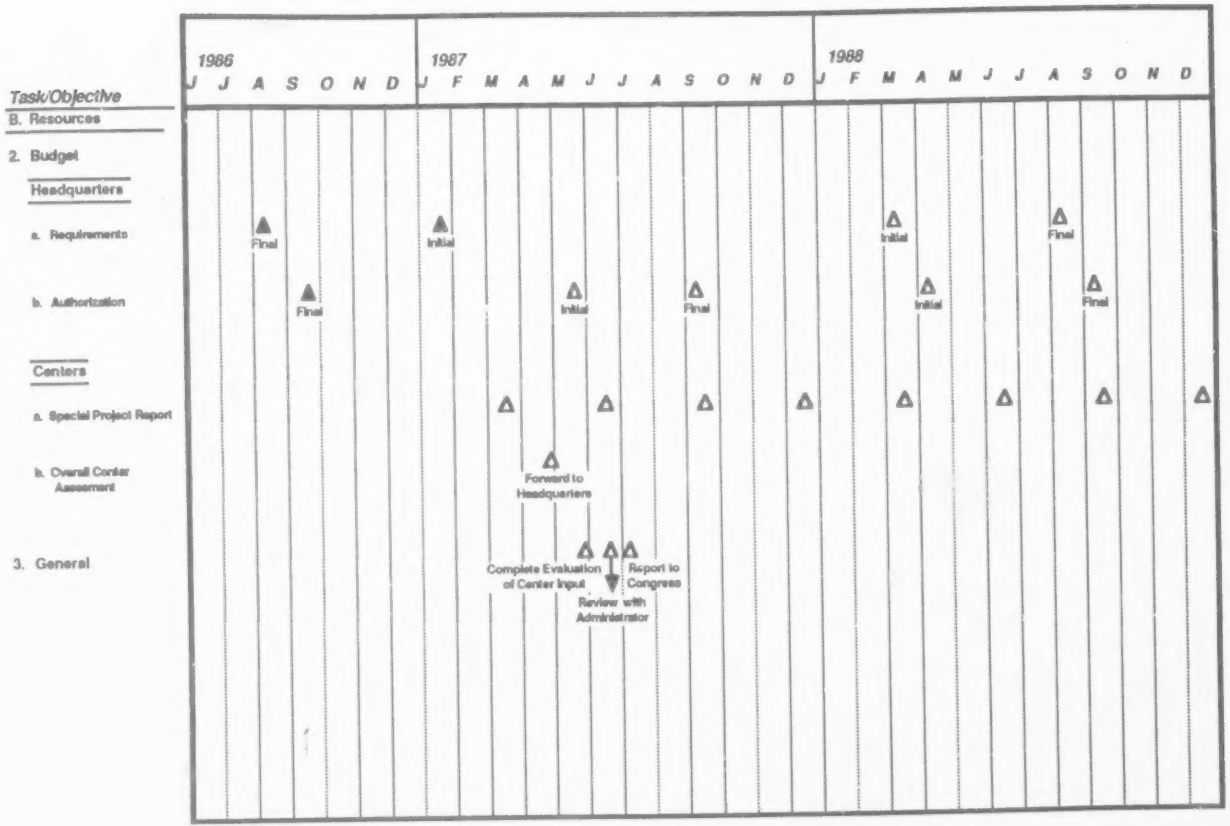

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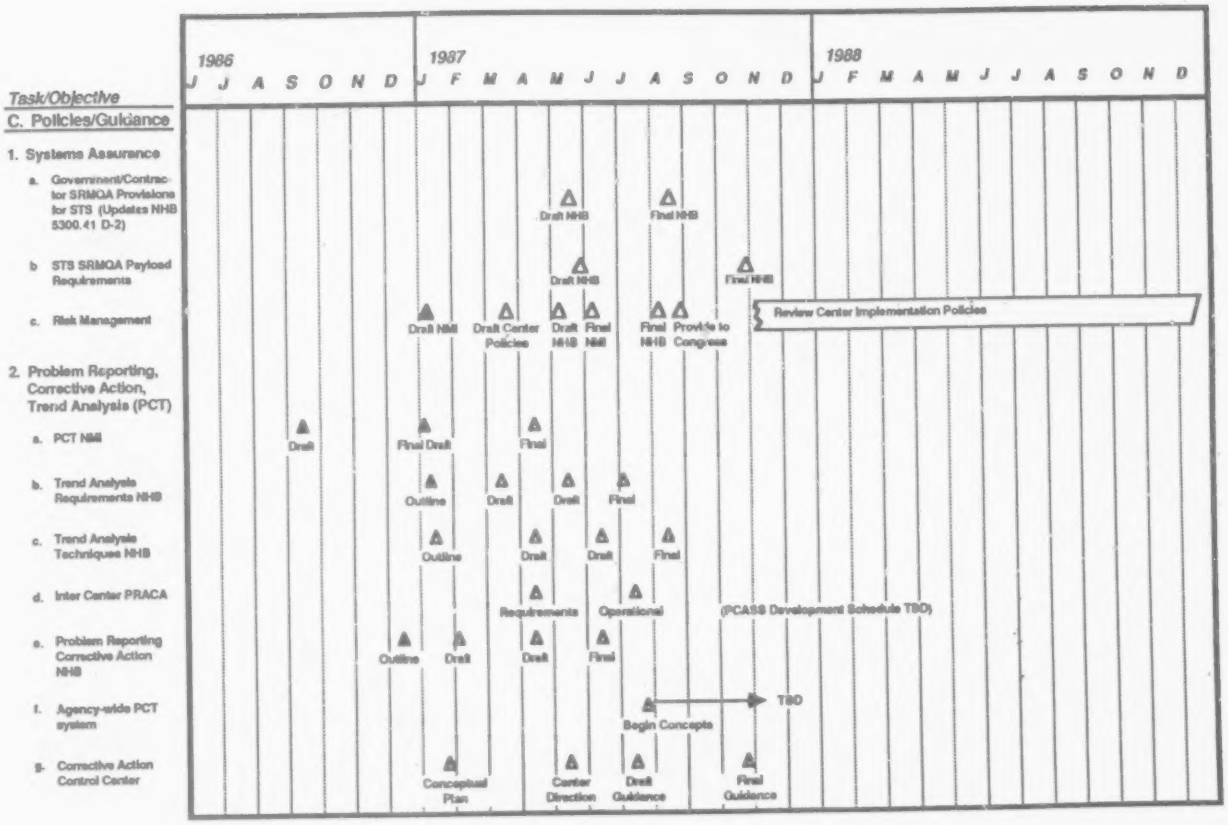

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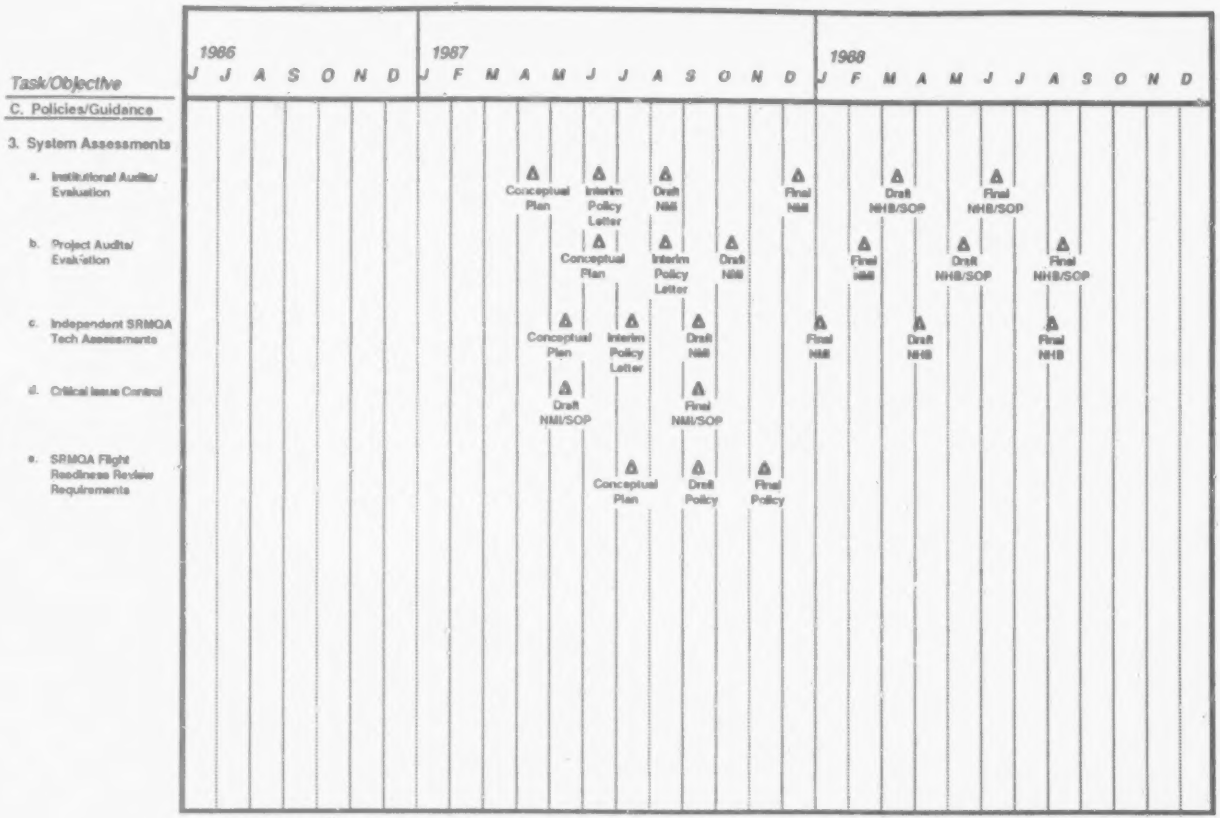

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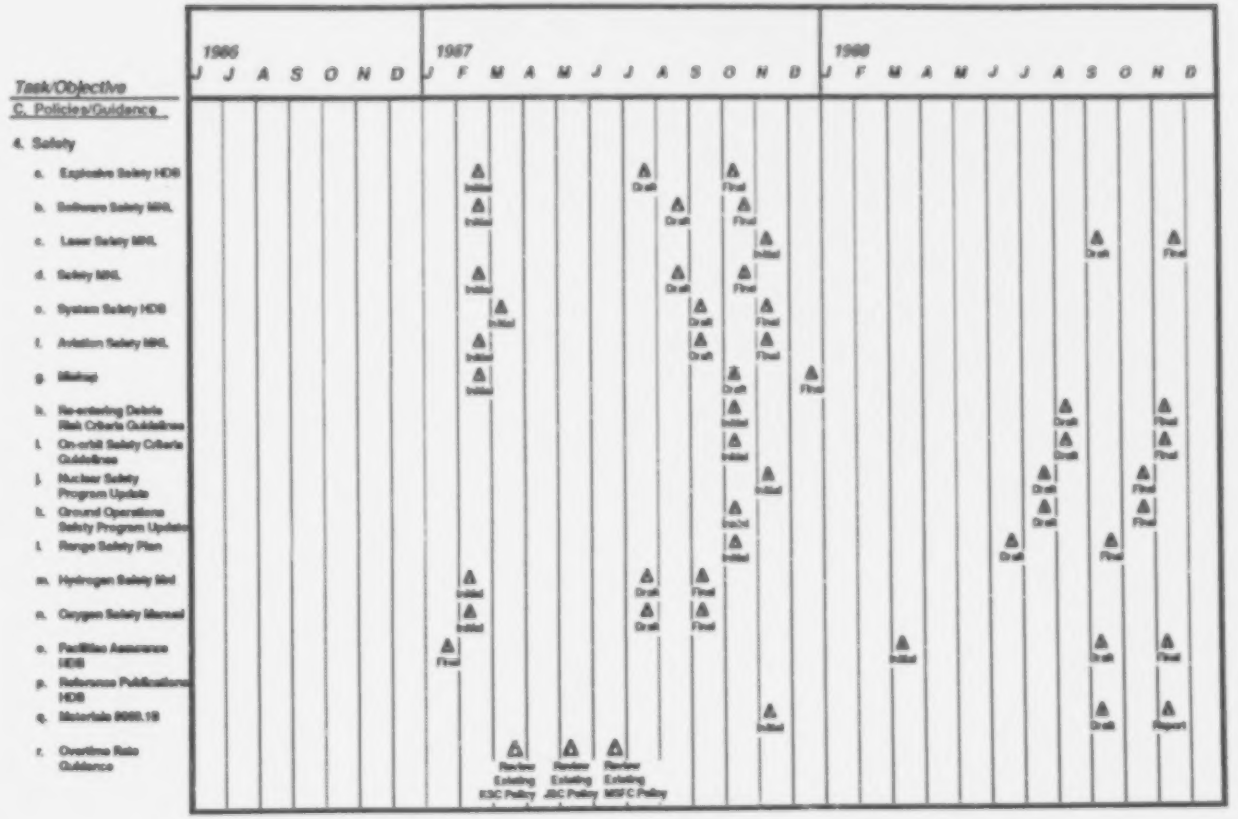
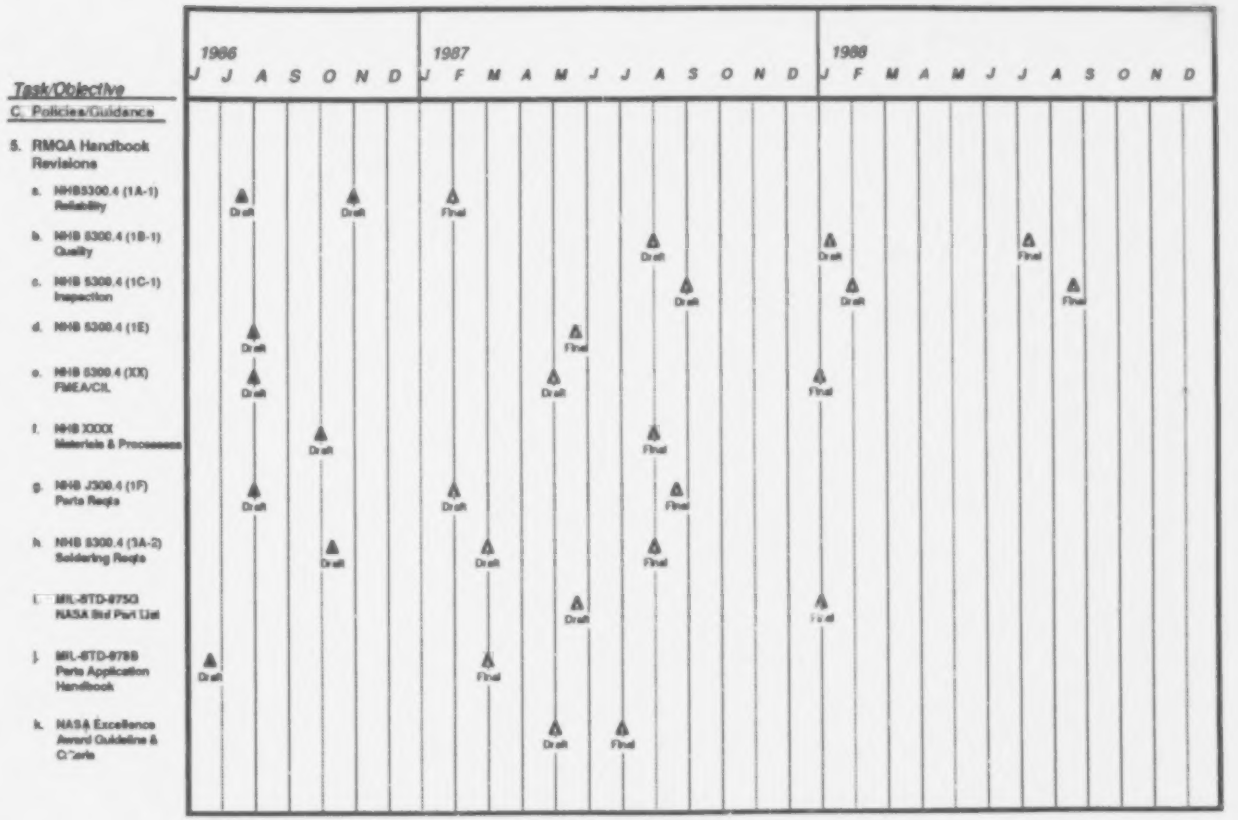

1986
J J A S O N D
1987
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
Task/Objective
C. Policies/Guidance
4. Safety
a. Explosive Safety HDB
b. Software Safety MHL
c. Laser Safety MHL
d. Safety MHL
e. System Safety HDB
f. Aviation Safety MHL
g. Mishap
h. Re-entering Debris Risk Criteria Guidelines
i. On-orbit Safety Criteria Guidelines
j. Nuclear Safety Program Update
k. Ground Operations Safety Program Update
l. Range Safety Plan
m. Hydrogen Safety Mnl
n. Oxygen Safety Manual
o. Facilities Assurance HDB
p. Reference Publications HDB
q. Motorbale 8080.19
r. Overtime Rate Guidance
Review Existing KSC Policy
Review Existing JSC Policy
Review Existing MSFC Policy

## NASA HEADQUARTERS SRMQA SHORT RANGE PROGRAM PLAN


1986
J J A S O N D
1987
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1988
J F M A M J J A S O N D
Task/Objective
C. Policies/Guidance
5. RMQA Handbook Revisions
a. NHB5300.4 (1A-1) Reliability
b. NHB 5300.4 (1B-1) Quality
c. NHB 5300.4 (1C-1) Inspection
d. NHB 5300.4 (1E)
e. NHB 5300.4 (XX) FMEA/CIL
f. NHB XXXX Materials & Processes
g. NHB 5300.4 (1F) Parts Reqts
h. NHB 5300.4 (3A-2) Soldering Reqts
i. MIL-STD-975G NASA Std Part List
j. MIL-STD-978B Parts Application Handbook
k. NASA Excellence Award Guideline & Criteria
Draft
Final

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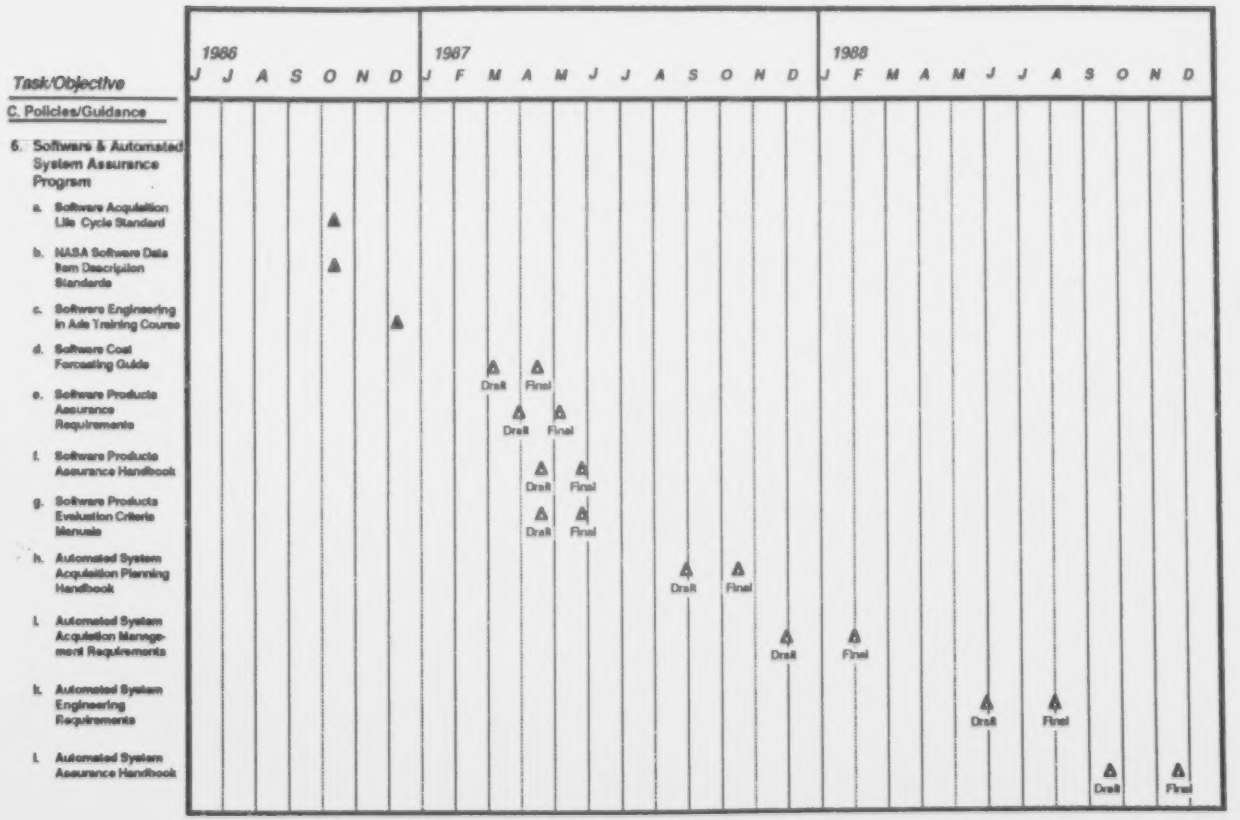
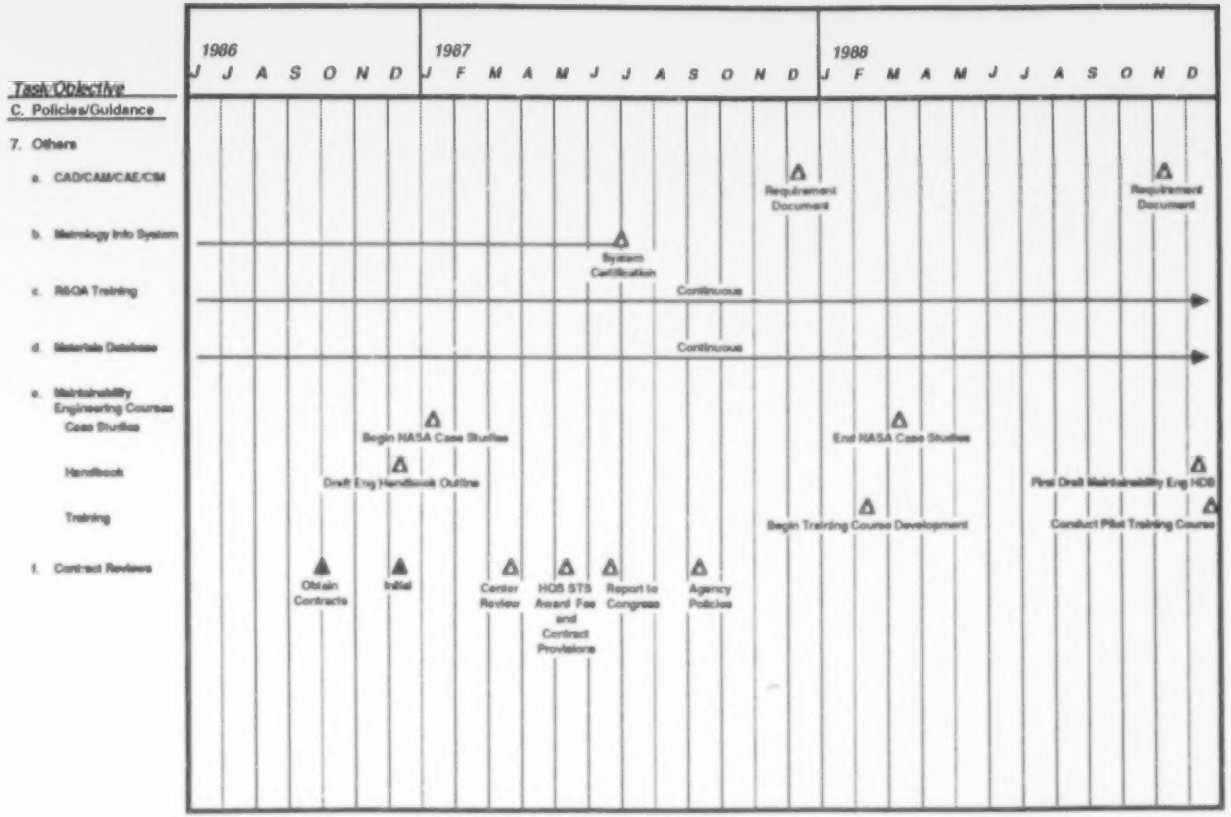

Task/Objective
C. Policies/Guidance
6. Software & Automated System Assurance Program
a. Software Acquisition Life Cycle Standard
b. NASA Software Data Item Description Standards
c. Software Engineering in Ada Training Course
d. Software Cost Forecasting Guide
e. Software Products Assurance Requirements
f. Software Products Assurance Handbook
g. Software Products Evaluation Criteria Manuals
h. Automated System Acquisition Planning Handbook
i. Automated System Acquisition Management Requirements
k. Automated System Engineering Requirements
l. Automated System Assurance Handbook
1986
J J A S O N D
1987
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
Draft
Final

## NASA HEADQUARTERS SRMQA SHORT RANGE PROGRAM PLAN



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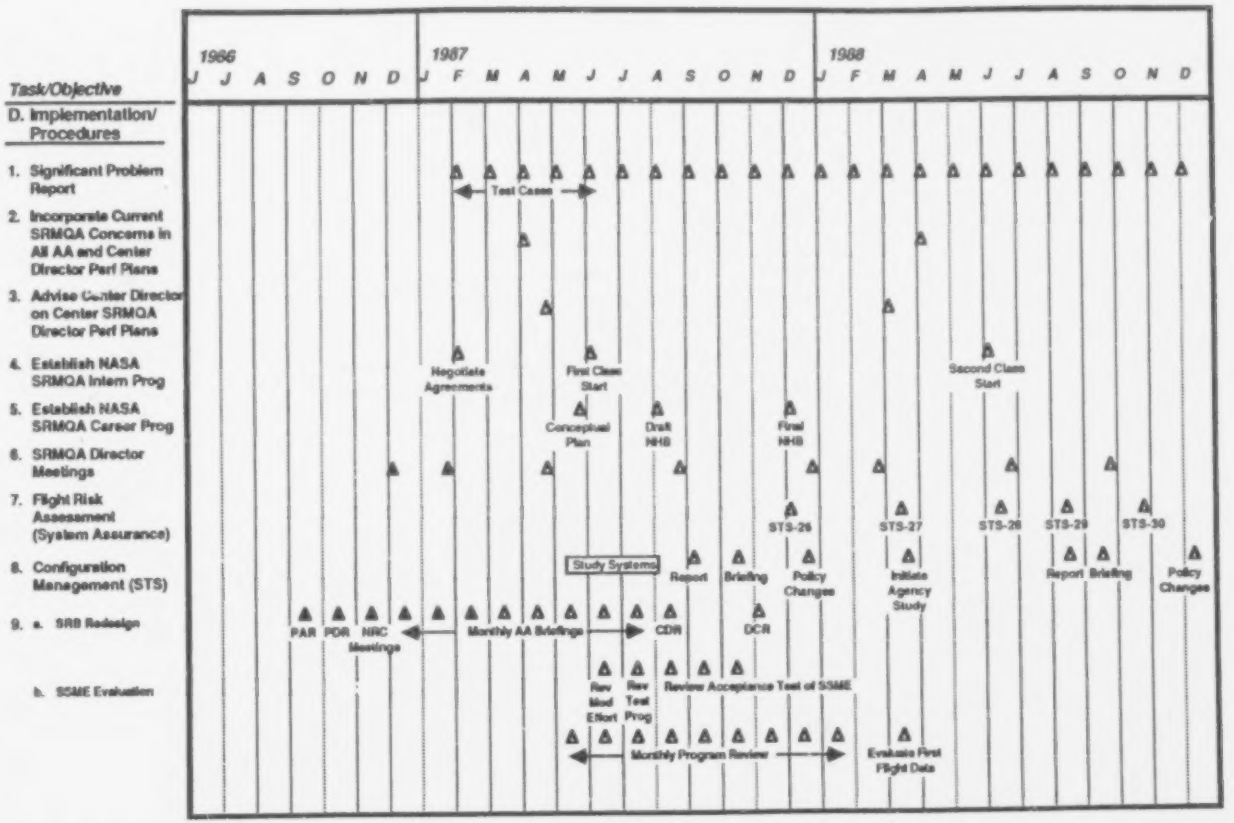

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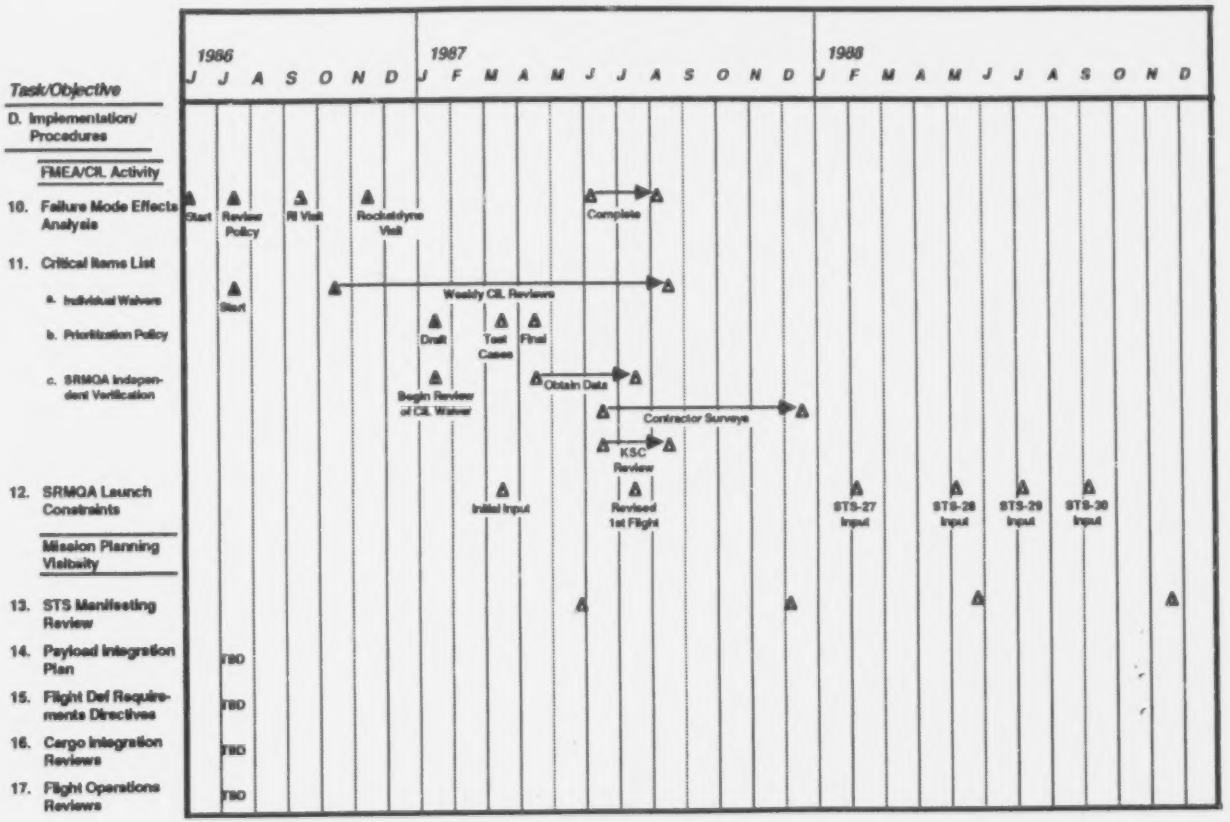

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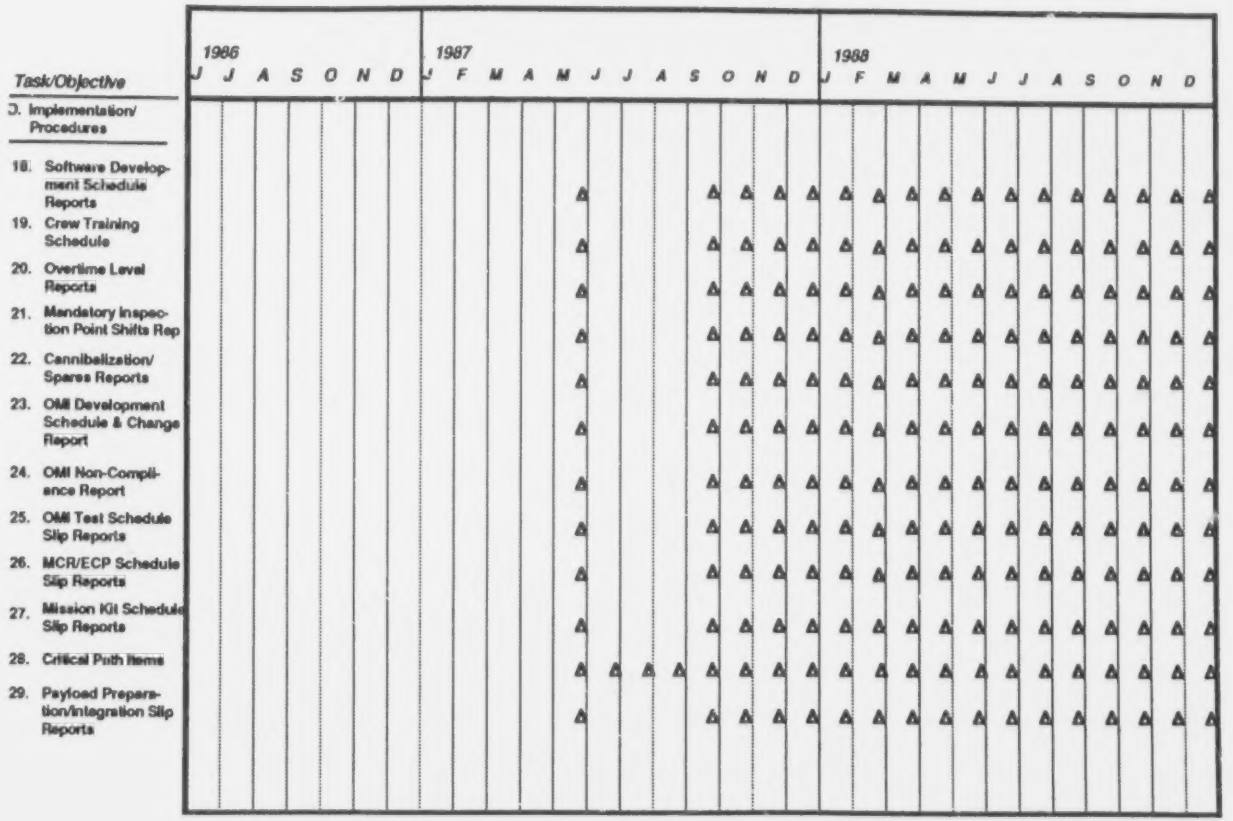
1986
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1987
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1988
J F M A M J J A S O N D
Task/Objective
D. Implementation/ Procedures
18. Software Development Schedule Reports
19. Crew Training Schedule
20. Overtime Level Reports
21. Mandatory Inspection Point Shifts Rep
22. Cannibalization/ Spares Reports
23. OMI Development Schedule & Change Report
24. OMI Non-Compliance Report
25. OMI Test Schedule Slip Reports
26. MCR/ECP Schedule Slip Reports
27. Mission Kit Schedule Slip Reports
28. Critical Path Items
29. Payload Preparation/Integration Slip Reports

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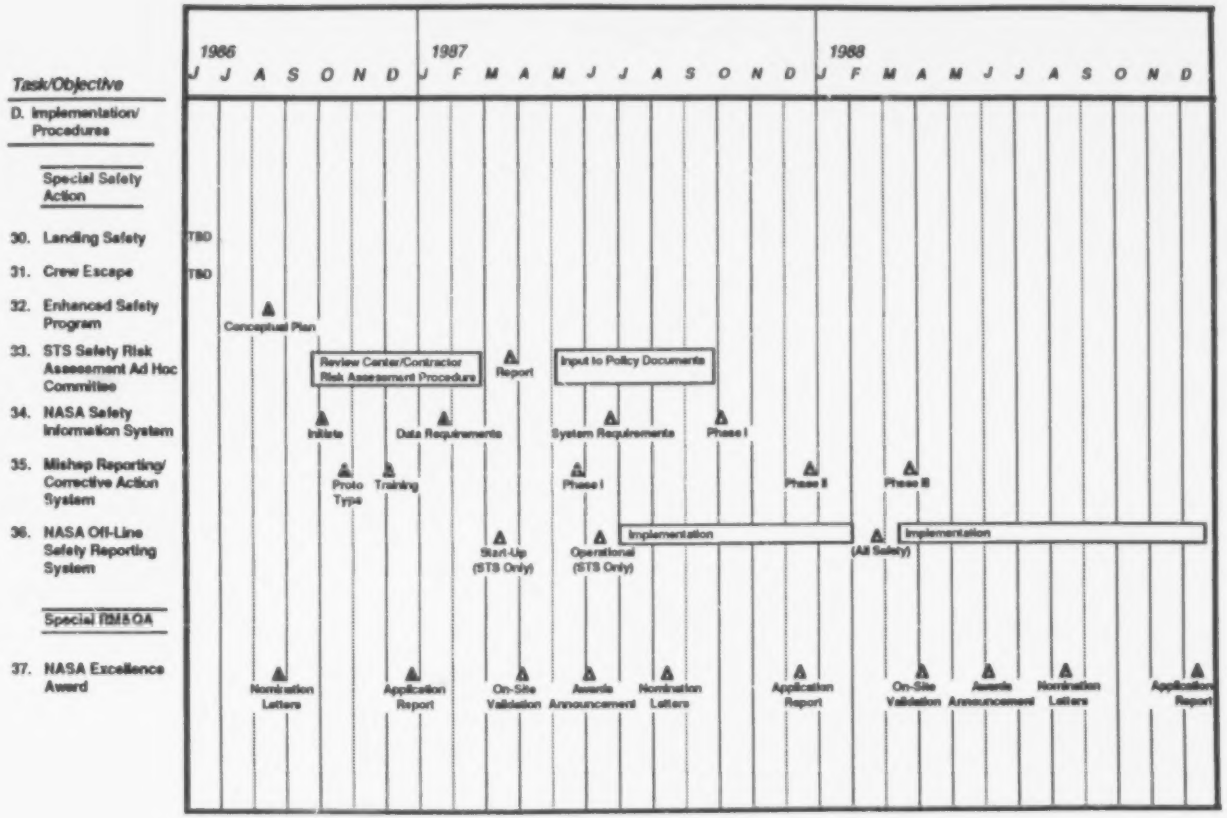

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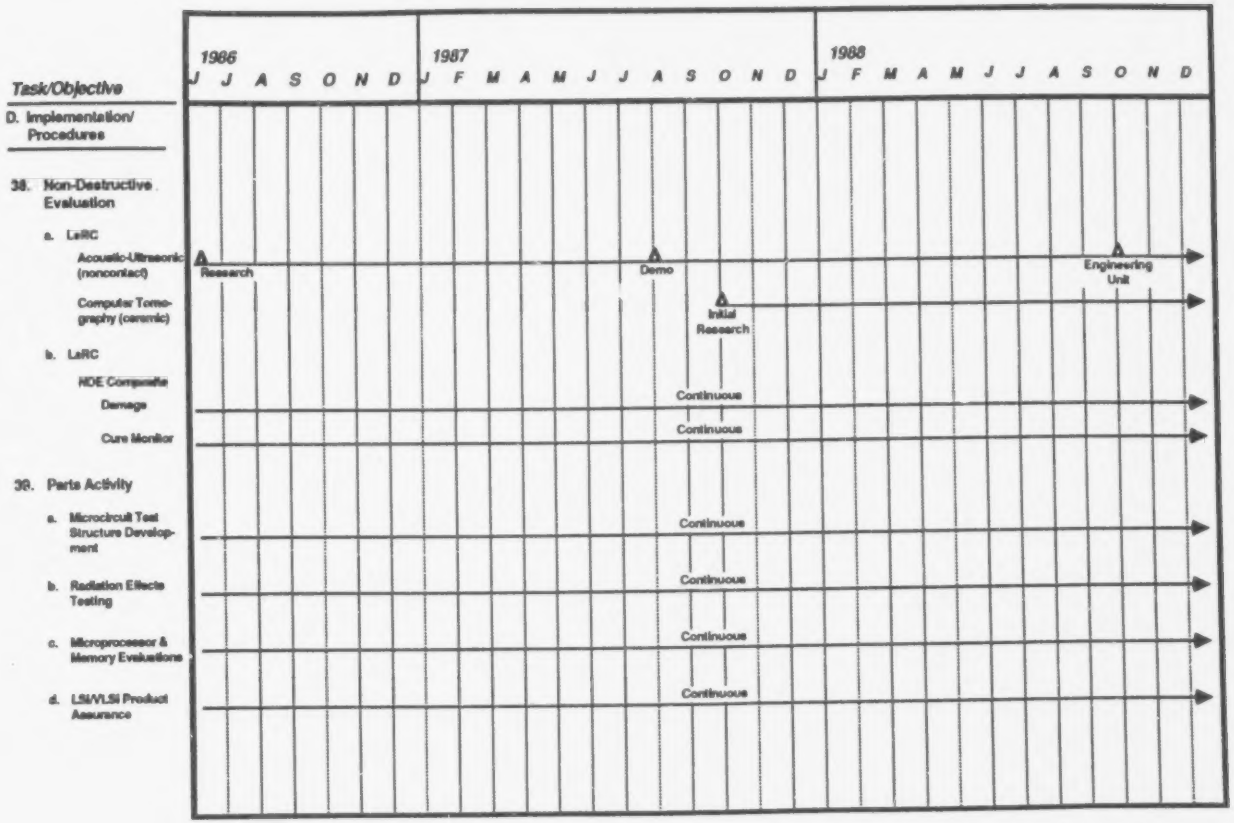

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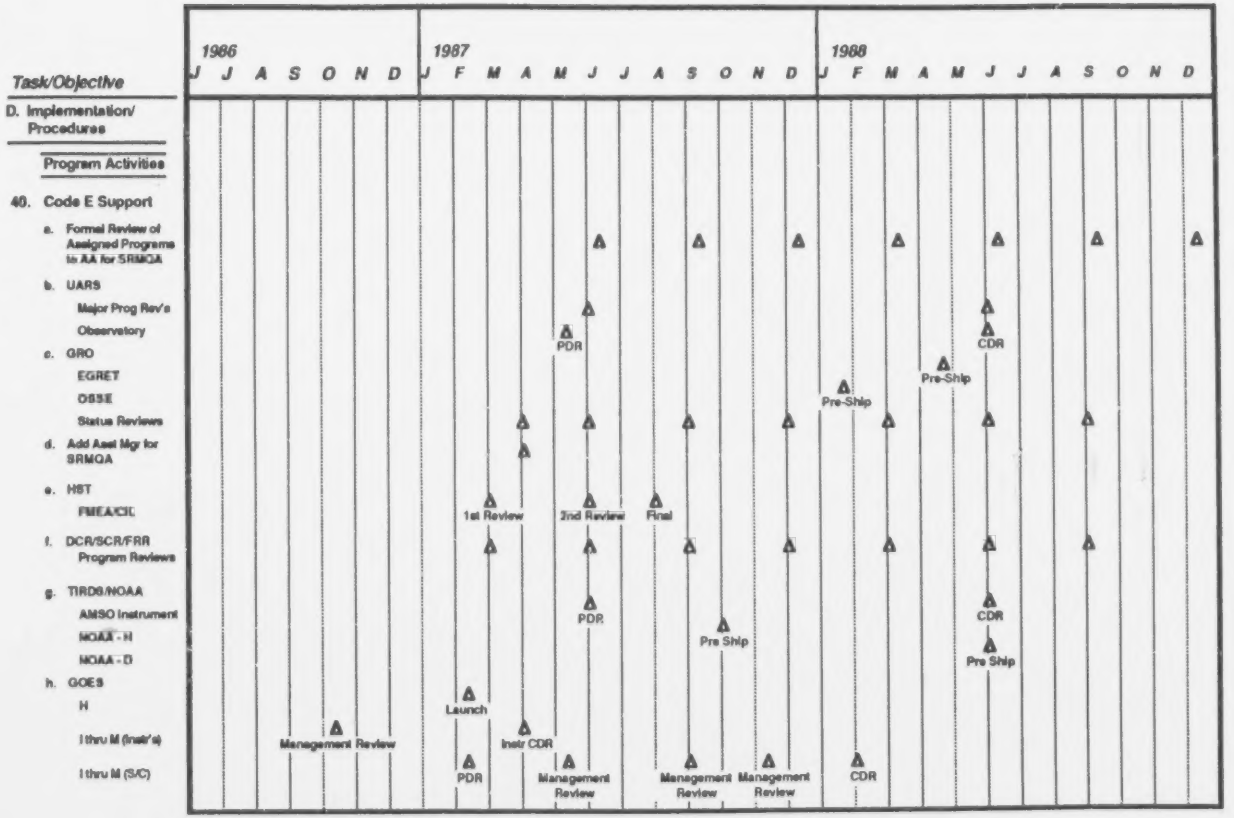

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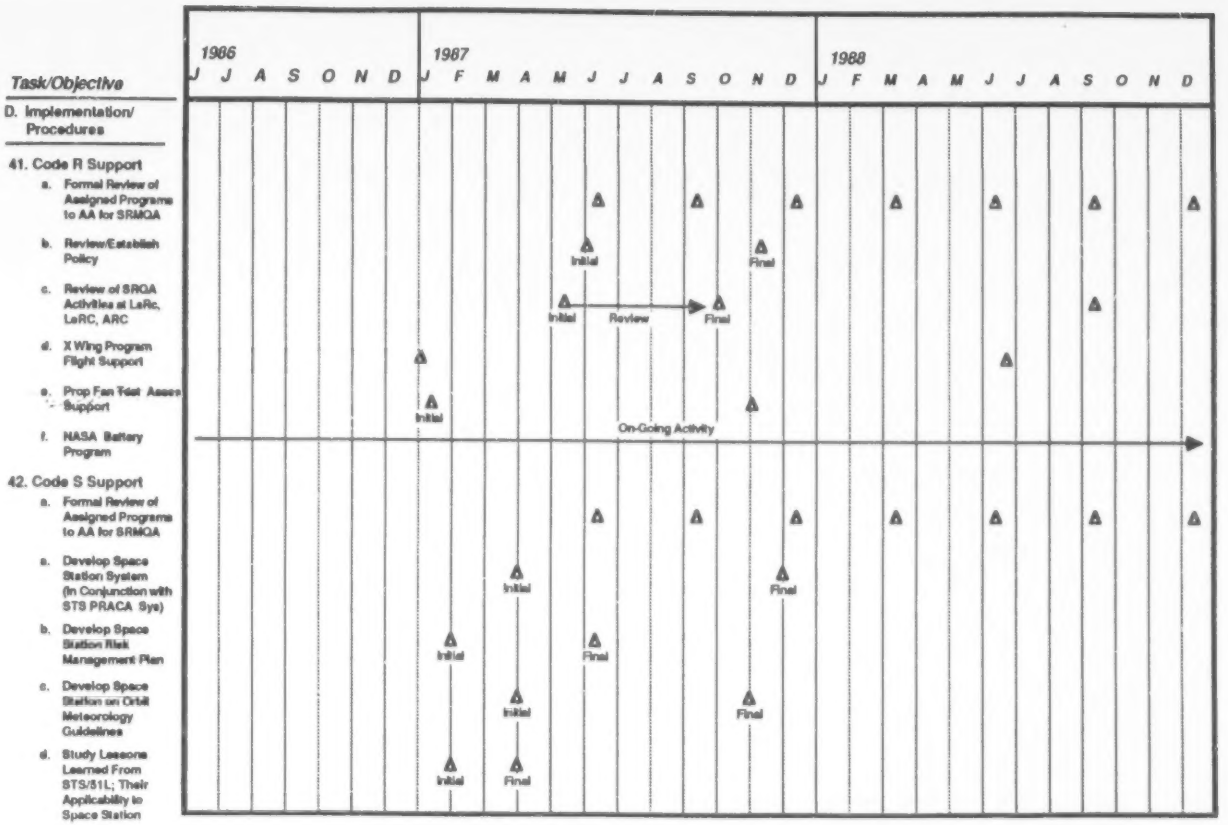
1986
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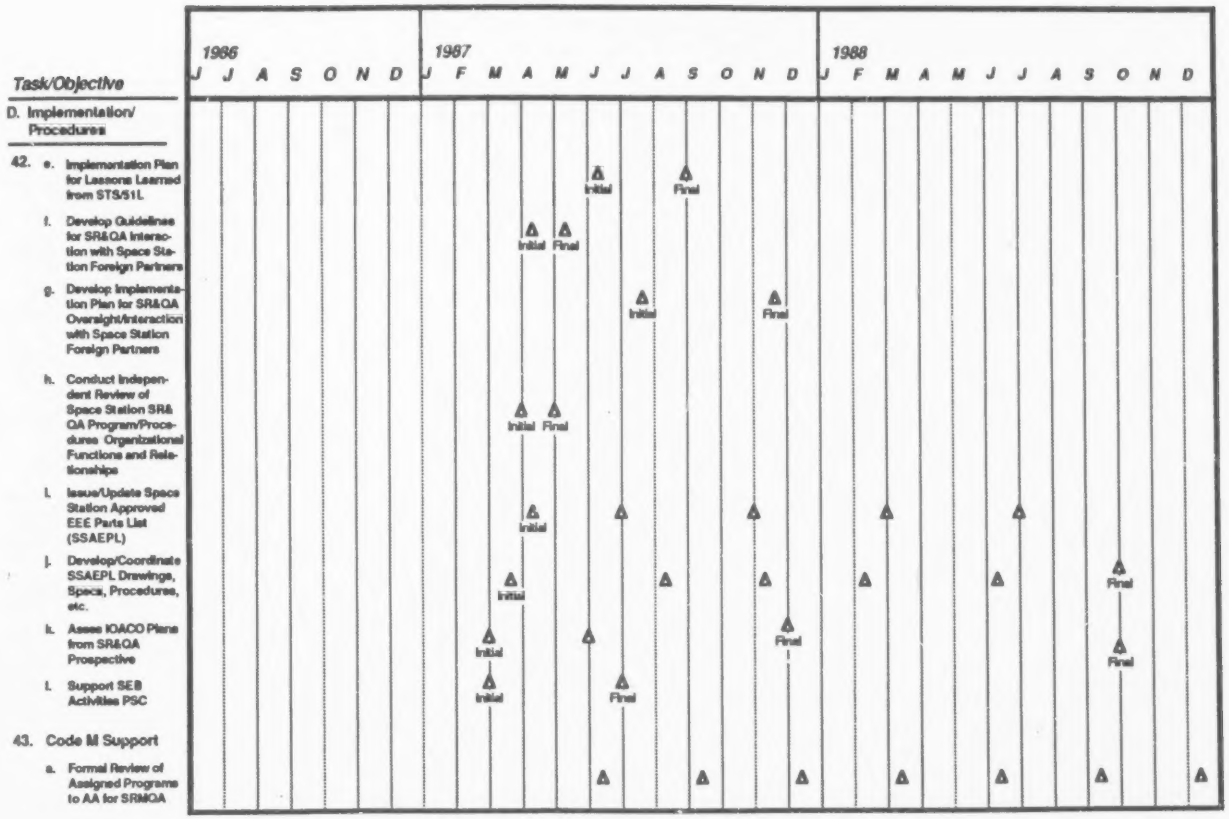
1987
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
Task/Objective
D. Implementation/ Procedures
41. Code R Support
a. Formal Review of Assigned Programs to AA for SRMQA
b. Review/Establish Policy
c. Review of SRQA Activities at LaRc, LeRC, ARC
d. X Wing Program Flight Support
e. Prop Fan Test Assess Support
f. NASA Battery Program
42. Code S Support
a. Formal Review of Assigned Programs to AA for SRMQA
e. Develop Space Station System (In Conjunction with STS PRACA Sys)
b. Develop Space Station Risk Management Plan
c. Develop Space Station on Orbit Meteorology Guidelines
d. Study Lessons Learned From STS/51L; Their Applicability to Space Station
Initial
Final
Review
On-Going Activity

## NASA HEADQUARTERS SRMQA SHORT RANGE PROGRAM PLAN


1986
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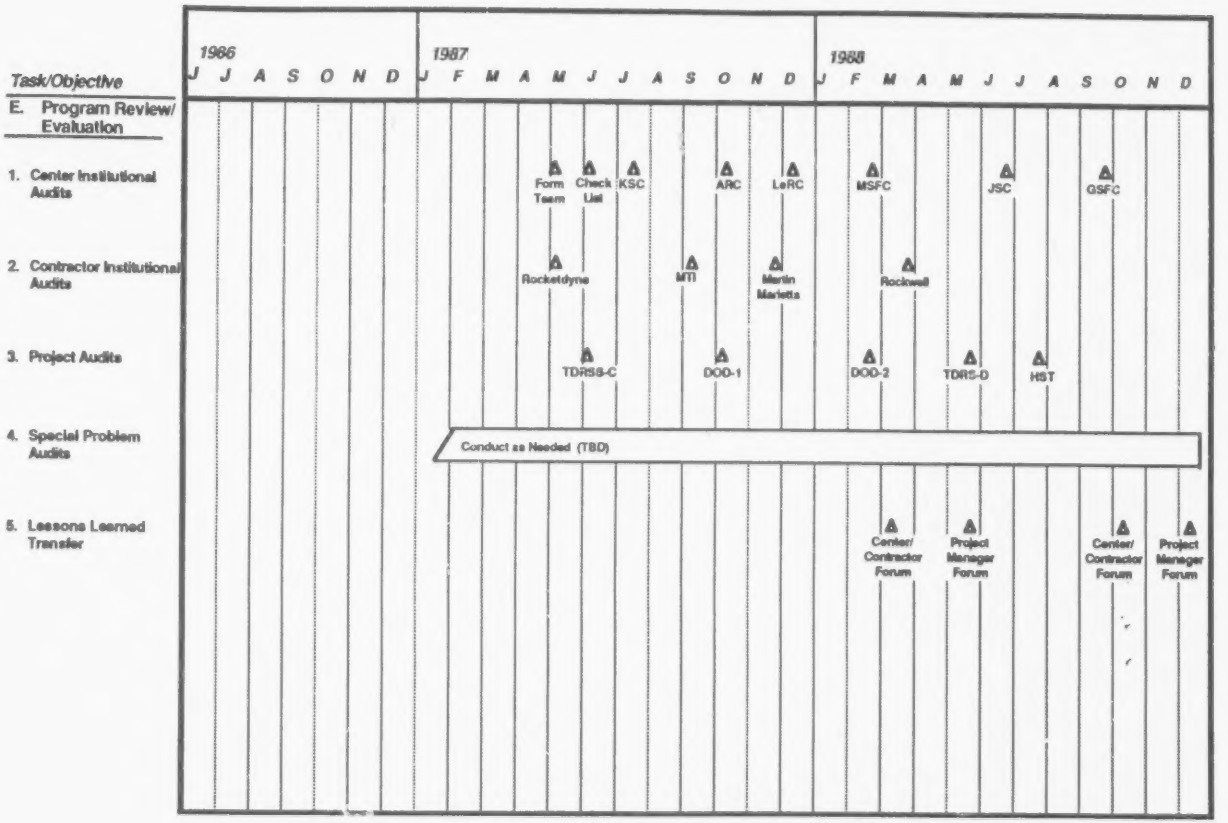
1988
J F M A M J J A S O N D
Task/Objective
D. Implementation/ Procedures
42. e. Implementation Plan for Lessons Learned from STS/51L
f. Develop Guidelines for SR&QA Interaction with Space Station Foreign Partners
g. Develop Implementation Plan for SR&QA Oversight/Interaction with Space Station Foreign Partners
h. Conduct Independent Review of Space Station SR& QA Program/Procedures Organizational Functions and Relationships
i. Issue/Update Space Station Approved EEE Parts List (SSAEPL)
j. Develop/Coordinate SSAEPL Drawings, Specs, Procedures, etc.
k. Asses IOACO Plans from SR&QA Prospective
l. Support SEB Activities PSC
43. Code M Support
a. Formal Review of Assigned Programs to AA for SRMQA
Initial
Final

## NASA HEADQUARTERS SRMQA SHORT RANGE PROGRAM PLAN



Mr. NELSON. What have you done that would not allow the events that occurred on the night of January 27, 1985 to reoccur?

Mr. RODNEY. We are developing a communication system and a working relationship with the center personnel where I expect I would be familiar with the situation as it had developed there and would have been in a position to have made that situation known. I believe that the way we are working in this particular case with the folks at Marshall, I have a working relationship with Alex McCool, who is my counterpart there, and in fact, I was talking to him this morning on a problem. I expect to have a good enough system of communication developed that I should be aware of it and it is my responsibility to take action in a case like that.

Mr. NELSON. So you are going to brood and oversee over the question of communication.

Mr. RODNEY. Yes, sir.

Mr. NELSON. What is in place in your operation to make sure that communication doesn't just go from the top down but comes from the bottom up?

Mr. RODNEY. That is a major effort that we have under way to develop that system. We are working it. To be quite frank, it is not in place today, but I expect to have it in place within the next few months. We have a tremendous amount of effort going there. It is a tough, tough problem.

Mr. NELSON. Give us some examples of what is your effort there.

Mr. RODNEY. The issue that we are working is to develop a system where at the base you have literally thousands of elements of data coming in, and we are working to show how at level 3 and level 2 and level 1, how we will filter, compact that data down to the significant issues.

Now, complementary to that, however, is really the informal communication that I have got to establish with the senior people at the centers. I mean no automatic, no mechanical data system will completely eliminate the——

Mr. NELSON. Yes, I understand what you are saying and I think it is true, but it is all hazy and vague, what you are saying. Specifically, would you, under the system that you have now inaugurated, would you have been a participant in that meeting that occurred on January 27?

Mr. RODNEY. Yes, sir, I think I should, I would have been.

Mr. NELSON. Under what you have set into place now?

Mr. RODNEY. Yes.

Mr. NELSON. You or one of your lieutenants?

Mr. RODNEY. That's correct, yes.

Mr. NELSON. Would you have the veto power over the launch?

Mr. RODNEY. Yes. I will be in a position and Dr. Fletcher expects me to give him a yes or no on the launch.

Mr. NELSON. What else in the launch decision will you participate in in the future?

Mr. RODNEY. I will be participating, I and my people will be participating in the whole tier of events that build up to the launch, and you are familiar to a degree with, I think, the total flight readiness review process. We will be a very active ingredient. I expect our people to take a positive stance at each level of that process.

Mr. NELSON. If there are icicles all over the launch pad, at some time in the future would you give a go for launch?

Mr. RODNEY. From what I understand of the technical issues involved with that, I would say, no.

Mr. NELSON. Why?

Mr. RODNEY. Well, my understanding at this time, and I need to get smarter in this issue, I might add, before we get there, is that the shuttle cannot tolerate very much ice damage. And I need to have a very good understanding of that issue before we get ready to fly; and I shall do so.

Mr. NELSON. When you say, ice damage, explain that?

Mr. RODNEY. Well, as you're well aware of, I believe, the thermal protection system on the shuttle is very prone to external damage. And there is data, and I'm now talking a little bit without all the facts, but I know there is a degree at which ice will damage those tiles.

Mr. NELSON. Rocco Petrone said that on January 27. From your review of what happened there, why did that message not get through? As it occurred, there was none that we know of.

Mr. RODNEY. Yes.

Mr. NELSON. But as you just stated, that is a real question about damage to the system. Looking back on January 27, why did that message not get through?

Mr. RODNEY. I'm no smarter on that issue than what I read in the Rogers Commission Report, and I have looked at that very carefully. And it apparently, the process that was in effect at that time did not require a literal positive statement of go or no go from the contractor. And the way it was postulated, he raised it as a concern but did not make a positive statement that he would not go.

I would expect us, in the future, that the contractors will be required to make a positive statement as to their readiness to go.

Mr. NELSON. You said that, were the scenario to reoccur, that you would be present at such a meeting like that, that occurred on January 27. Is there a requirement now, in the new NASA reorganization, that you or one of your lieutenants would be at such a meeting?

Mr. RODNEY. That is implicit right now. We are in the process of developing written procedures. I do not right now have a document that says this. However, Dr. Fletcher has told me very explicitly that, that shall occur.

Mr. NELSON. Okay. Then we're going to rely on what you said, that that's going to stop being implicit and it's going to be explicit.

Mr. RODNEY. Yes, sir. There will be an explicit procedure on that subject.

Mr. NELSON. Are you having difficulty getting people to come to Washington, in your office, because of the cost of living differential between that and the other Centers?

Mr. RODNEY. Yes, sir. In fact, I can tell from my own personal experience on this issue, the combination of the cost of living in Washington, the NASA pay scales, and more especially the NASA relocation policies—and I shouldn't say, NASA, I believe they're Government relocation policies—make it extremely difficult, both

to get people from within NASA, and even more so, to get people from outside of NASA.

Mr. NELSON. Well, what can you do about it?

Mr. RODNEY. I personally can't do very much with it. I have to work within that structure.

Mr. NELSON. So, in essence, what you're saying is, you're not going to get the people that you want because, obviously, they can't take the financial beating to move to Washington; is that the bottom line?

Mr. RODNEY. Well, I'm not getting people as fast. I've been getting people, and I will continue to get people. I can work on people. Every once in a while you can find somebody that's willing or is capable of withstanding the financial impact. Now, we're working hard on it, but it is a difficult situation. And I personally feel that it needs significant correction if we're going to get good strong people.

Mr. NELSON. We would like a progress report from you on that issue when we start getting back into the *Challenger* hearings.

Okay. Mr. Hefley, Mr. Mineta, Mr. Nagle.

Mr. Hefley.

Mr. HEFLEY. No questions.

Mr. NELSON. Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

Mr. Rodney, could you explain what happened to the Office of the Chief Engineer?

Mr. RODNEY. Well, the Chief Engineer Office per se no longer exists.

Mr. MINETA. Have the functions there been integrated into your office?

Mr. RODNEY. Some of the office function, prior to my arrival from best I can reconstruct, it was at least 80 percent involved with what is now, in my estimation, pure SRM and QA type function, maybe even more than that. And there are a few elements that I have continued to operate that you might say are marginal in the area of SRM and QA, but they are not significant to my attention to the basic job.

Mr. MINETA. And your background prior to coming to this job was what?

Mr. RODNEY. I've had experience in the quality and safety fields; I've had significant experience in tests; and in various elements of engineering; and in manufacturing.

Mr. MINETA. Now, along that line, because of your background, and I think it was to the study of the automobile industry where safety was sort of a separate function, but in the automobile industry they found that really safety is really each worker's responsibility.

I'm wondering whether or not in sort of, not isolating, but putting this all under one—in one office, apart from the engineering directorate, whether or not it doesn't remove some of that responsibility from the engineering departments, either at Marshall Space Center or Houston or Kennedy, rather?

Mr. RODNEY. Well, that is a good observation, very astute observation, Mr. Mineta. We have to be very careful that people recognize that the safety that is in this title is an assurance function.

Inherently, safety is responsibility of the operating agencies. In fact, one of the specific tasks that I have done since I've been here is, I have been having inserted into each of the Center Directors job description or responsibility, a statement that they are responsible for the safety of their operations and services, because they have to build that into their engineering group, and into their manufacturing groups, and what have you. What I am doing is providing a framework to make sure that that happens. But I still cannot design the safety, and the safety has to be done by the designers. I can make sure that he does it. But he has to recognize his responsibility.

Mr. MINETA. Now, given that framework and the increase in the budget up to the 16.2 million for your function, do you feel that that is sufficient to do that?

Mr. RODNEY. Yes. I think that we can do a very adequate job within those constraints.

Mr. MINETA. Then, I guess, proof of the pudding is in terms of an accident not occurring. But when an accident occurs everyone is sort of pointing their finger——

Mr. RODNEY. Yes, sir.

Mr. MINETA [continuing]. All over the place. And given this kind of separation of—you say framework is there. You've got enough people to oversee it. But how do we make sure that if something were to happen, that we don't have that kind of finger pointing?

Mr. RODNEY. I'm not sure that that is possible. One of the things that I always tell people is, if you have a success, the safety and quality folks get little credit for that success. The engineers did a good job designing; the manufacturing people did a good job building it; and the test and operation people did a good job of operating it. It's only when you have a failure that we get into the business. Then, we have to accept a fair share of the responsibility that our assurance functions didn't do the job.

Mr. MINETA. And the program people are going to point to the safety people, and the safety people are going to point to the program people.

Is there any way to eliminate or to try to narrow that focus for responsibility?

Mr. RODNEY. I wish I had an answer to that. No. I've been in this business off and on for a long time, and I don't have any real answer for that. What we have to do is, really, ensure that we don't get into that posture, that we don't have a failure.

Mr. MINETA. In your statement, of course, you speak of the space flight safety panel; I'm wondering if you could expand on the role of that panel.

Mr. RODNEY. Well, that panel is an independent group. It's attached to my staff, and it consists of Brian O'Connor who is an astronaut, and a representative of the operations group from Johnson, Kennedy, and Marshall. And they have the charter to look at any aspect of the operation and provide us with an independent assessment. They also will react to specific requests of mine, to provide me with their insight into an issue, so that it will help me arrive at a decision.

Mr. MINETA. Let me ask about—you've used this phrase, independent, what does that mean and how independent is it really?

Mr. RODNEY. It is outside the normal programmatic channels. In other words, I can initiate an action without getting permission from Admiral Truly, if I want to. Now, ordinarily I will work with him on something, and that's the way I would ordinarily do it. But if I really want to go off and do an independent assessment, whether he likes it or not, I can go ahead and do it.

Mr. MINETA. I also would like to ask about that backup, what you call, a backup safety reporting mechanism, I'd like to have you explain that a little more.

Mr. RODNEY. You're talking the NASA safety reporting system. This is a system that's a little bit of kin to the popular term hotline, although I'm trying not to use that term, and it is to provide an anonymous, if the person wants to be anonymous, reporting system to report problem areas which they feel they cannot get adequate satisfaction through normal channels.

It is a direct clone, I might add, of the existing FAA system that they use for reporting near misses and operational problems. We've done very little. Batelle Institute is going to work it for us in the same sense that they're working it for FAA through NASA.

Mr. MINETA. And do you feel that this is necessary because you're afraid or is there a fear on the part of NASA employees to report through normal reporting channels, their concerns?

Mr. RODNEY. We are doing everything we can to eliminate that issue. However, you never can completely eliminate somebody saying that they're afraid to report because of their job. Maybe it's their own mentality that makes them afraid, but regardless, there is always that little bit of undercurrent; and as a last resort we want to give people this opportunity.

Mr. MINETA. Very well. Thank you very much, Mr. Rodney.

Mr. Chairman, thank you very much.

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. I think it was Blackstone that said that an ounce of logic is worth a pound of history. I think it was Blackstone. I look at what you have presented to the committee this morning in terms of the steps you are taking to implement safety and quality assurance and risk management, and frankly, I am kind of shocked that they weren't in place a long time ago. It means if a safety engineer would have walked in here in 1982 and said that standards of safety engineering are not being met, I don't think this committee would have left that budget at $9,200,000,000 but probably would have taken steps to increase it.

My concern is that NASA, given its drive to achieve, how do we avoid in the future seeing that safety considerations give way to budgetary considerations, that launch projects give way to safety considerations? How does this committee as an oversight committee ensure that we are adequately informed if there are disagreements within the community about the safety of a specific project?

Mr. RODNEY. That is an excellent question, Mr. Nagle. I am very concerned on that issue. What I am in the process of doing is developing a structure where I can understand our resource requirements, both people, dollars, and get them so well established in the sense of how much safety dollars we should have as a percentage of our program or percentage of a center activity and what have you, institution.

I want to get those well documented in the next several years so that sometime in the future when things change and people get less excited about safety, that there will be a ready reference base that oversight groups such as yours can readily see if somebody is shortchanging the safety or quality world. I intend to have that in place in the next period of time.

Mr. NAGLE. One of the principles of safety engineering is that you anticipate human error, and you more or less assume that if you put a man on a blitz press, he runs that eight hours a day and it makes two revolutions a minute, but at some point through inadvertence or human error he is going to put his hand at the impact point, so you put a shield on the machine to guard against that human error.

The program you have outlined for us this morning is still, however, I think you would concur, interagency driven and subject only, except for your report to us, to interagency review. That would be fair, would it not?

Mr. RODNEY. Yes. On the other hand, we do have to recognize the presence of such agencies as the ASAP, which is totally independent.

Mr. NAGLE. Tell me what ASAP is.

Mr. RODNEY. Oh, I'm sorry. The Aerospace Safety Advisory Panel, which is a congressionally mandated group that has been in existence for some time and is chaired now by Joe Sutter, a retired Boeing vice president and one of the outstanding aerospace leaders in the country. He has a very strong group of people supporting him on that committee.

We have NRC right now doing a lot of oversight. There is a fair amount——

Mr. NAGLE. What is NRC?

Mr. RODNEY. The National Research Council.

Mr. NAGLE. All right.

Now, are they scheduled to—once you get your system in place, which in my judgment should have been in place a long time ago, and that is not your fault—are they scheduled to do any independent evaluation of the system?

Mr. RODNEY. The ASAP very definitely is mandated to keep a continuous oversight of both my system and the overall, any other aspect that they see fit that might have impact on the safety performance of NASA.

Mr. NAGLE. Are they scheduled to do periodic reviews?

Mr. RODNEY. Yes, sir.

Mr. NAGLE. What is the timetable of those reviews?

Mr. RODNEY. I can't answer formally. They are a very active group. I can give you the details of their meeting schedule if you would like. I don't have it currently with me.

Mr. NAGLE. I am curious to know are they scheduled to do a periodic evaluation, in depth, of the safety procedures that you propose to implement or are implementing at NASA?

Mr. RODNEY. They are mandated to once a year give the Administrator a detailed report of their yearly activity. In fact, that report was just completed and given to us last week, I believe.

Mr. NAGLE. When you say a yearly report to give to the Administrator, are you saying to you or to Dr. Fletcher or to who?

Mr. RODNEY. To the Administrator. They are congressionally mandated to give it to the Administrator.

Mr. NAGLE. I am sorry, I am not being clear. Who is the Administrator?

Mr. RODNEY. Dr. Fletcher. I am sorry.

Mr. NAGLE. Dr. Fletcher. And are they mandated to share that report with us?

Mr. RODNEY. It is a public report, yes, sir.

[The information requested above follows:]

(Exhibit I)

Material requested for the record on page 42, line 965, by Mr. Nagle, on March 18, 1987

PANEL ACTIVITIES FOR CALENDAR YEAR 1986

| DATE | SITE | SUBJECT |
|---|---|---|
| 2/3-4-5 | Ames Research Center | Life Sciences Advisory Committee Meeting |
| 2/11 | HQ | Statutory Annual ASAP meeting with Administrator |
| 2/21 | Langley Research Center | X-29A Aircraft |
| 3/11 | Langley Research Center Control | Shuttle Landing Gear and Tires, Structures, Stability and |
| 3/10-13 | Sikorsky Pratt & Whitney West Palm Beach | X-Wing Propulsion Test Program and Safety |
| 3/18 | MSFC | STS Element Status |
| 4/1-3 | JSC | Space Shuttle, Space Station, Aircraft Operations |
| 4/10 | Lewis Research Center | Centaur management and technical status |
| 4/22 | Lewis Research Center | Centaur program discussion with staff from House HUD-Independent Agencies subcommittee |
| 4/29-30 | PAFB, FL | Intercenter Aircraft Operations Panel |
| 4/30-5/1 | HQ | STS, Space Station Logistics |
| 5/8 | U.S. Senate | Senate Testimony regarding ASAP Annual report and "where do we go from here." |
| 5/15-16 | HQ | Life Sciences Advisory Committee Meeting |
| 5/15 | U.S. House accident | Testimony concerning 51L |
| 5/20 | Rocketdyne Canoga Park, CA | SSME status and activities for first flight |

| | | |
|---|---|---|
| 5/21 | Vandenberg Air Force Base, CA | H2 exhaust duct problem, activities leading to first mission, SPC operations. |
| 5/21 | U.S. House | Quality Assurance Hearing |
| 5/21 | Langley Research Center | National Aerospace Plane |
| 5/21-22 | Sikorsky, CT | X-Wing Discussions on Flight Simulators and Rotor Blades |
| 6/17-19 | MSFC | SRM Redesign, SSME status |
| 6/19-20 | JSC | Space Station Engineering and Operations Safety Review |
| 7/1 | Vandenberg Air Force Base, CA | Hydrogen Exhaust Problem |
| 7/24 | HQ | Systems Safety |
| 7/24 | JSC | Space Station Engineering and Operation Safety Review |
| 7/24 | Lewis Research Center | National Aerospace Plane (propulsion system) |
| 7/29-30 | Sikorsky, CT | X-Wing RSRA Flight Readiness Review |
| 8/7-8 | HQ | Life Sciences Advisory Committee Meeting |
| 8/12-13 | Sikorsky, CT | X-Wing RSRA Flight Readiness Review |
| 8/19 | Sikorsky, CT | X-Wing Safety program |
| 8/20 | HQ | Probabilistic Risk Assessment Approach |
| 8/25 | HQ | ASAP Activities |
| 8/26-27 | KSC | NASA/SPC Launch Processing Operations |
| 9/23-25 | Denver, CO Martin-Marietta | FMEA/CIL, Space Station Safety |
| 9/23 | MSFC | Probabilistic Risk Assessment |

| | | |
|---|---|---|
| 10/3 | HQ | PRCB/FMEA/CIL |
| 10/7 | HQ | ET Tumble Valve Waivers |
| 10/16 | HQ | SRM Preliminary Design Review |
| 10/17 | Seattle,WA | ASAP Activities |
| 10/22-24 | Harlingen TX | Intercenter Aircraft Operations Panel |
| 10/21-23 | Ames Research Center | X-Wing Flight Readiness Review |
| 10/29 | JSC | Probabilistic Risk Assessment |
| 11/7 | HQ | Probabilistic Risk Assessment |
| 11/14 | JSC | STS Computer Hardware/Software |
| 11/20 | HQ | Meeting with NASA Administrator re: ASAP Factfinding |
| 11/20-21 | Langley Research Center | Non Destructive Evaluation for Solid Rocket Motor |
| 11/24-25 | HQ | Life Sciences Advisory Committee Meeting |
| 12/4-5 | KSC | NASA/SPC Launch Processing Operations |
| 12/15-16 | JSC | Space Shuttle, Space Station Computer Hardware/Software |
| 12/17 | HQ | Probabilistic Risk Assessment |

National Research Council Review Panel Participation

| | | |
|---|---|---|
| 7/7-8 | Los Angeles, CA | NRC Solid Rocket Motor Redesign Panel |
| 7/17-18 | Morton Thiokol | NRC Solid Rocket Motor Redesign Panel |
| 7/21-22 | Washington, DC | NRC Panel on STS Flight Rate and Utilization |
| 8/6-8 | KSC/MSFC | NRC Solid Rocket Motor Redesign Panel |
| 8/11-12 | Washington, DC | NRC Panel on STS Flight Rate and Utilization |

| | | |
|---|---|---|
| 9/10-12 | MSFC | NRC Solid Rocket Motor Redesign Panel |
| 9/16-18 | Washington, DC | NRC Panel on STS Flight Rate and Utilization |
| 9/22-23 | Washington, DC | NRC Criticality Review and Hazard Analysis Audit Panel |
| 10/9-10 | Washington, DC | NRC Solid Rocket Motor Redesign Panel |
| 10/27-28 | Rocketdyne Canoga Park, CA | NRC Criticality Review and Hazard Analysis Audit Panel |
| 11/10 | Washington, DC | NRC Criticality Review and Hazard Analysis Audit Panel |
| 11/20-21 | Washington, DC | NRC Solid Rocket Motor Redesign Panel |
| 12/15-16 | JSC | NRC Criticality Review and Hazard Analysis Audit Panel |

Mr. NAGLE. Thank you.

Then one question I think I would like to ask for the record, if I could. We understand that the baseline design for the Space Station does not include a lifeboat to return the crew to Earth in the event of emergency. I guess I would like to know your opinion about that situation.

Mr. RODNEY. My opinion is that we need a crew—if you want to call it lifeboat, some system, and I am fighting actively for that system. Whether it is in the baseline design or not, I fully will be fighting for that all through the program.

Mr. NAGLE. I have been around here long enough to know that we ought to call it emergency exit vehicle, and we can refer to it as EEV or something like that.

Mr. RODNEY. It is a CERV, crew emergency rescue vehicle.

Mr. NAGLE. Crew emergency rescue vehicle. Is there a little old lady down there that thinks up these things?

Mr. RODNEY. I don't know.

Mr. NAGLE. Finally, if in the event that decisions are made about safety that in your judgment are budget driven or launch schedule driven, do we have your assurances, even though your responsibilities are to Dr. Fletcher, that if you feel those decisions are in error, place jeopardy to the crew, we have your assurances that you will directly inform us of your dissatisfaction?

Mr. RODNEY. I will not be bashful about informing anybody I could talk to on the subject, to tell you the truth.

Mr. NAGLE. Thank you very much.

Mr. NELSON. Mrs. Morella, Mr. Packard, Mr. Walker, Mr. Buechner.

Mrs. MORELLA. Thank you, Mr. Chairman. To Congressman Nagle, there's probably a little old man who was involved in that——[Laughter.]

Mr. NAGLE. Congressman Morella, men lack the creativity necessary to do that task.

Mrs. MORELLA. None of them could do it.

Dr. Colladay, it's nice to see you again. Yesterday I was on the other side at Energy, Research and Development. You can see how we have to be many places.

Mr. Rodney, in listening to your comments and scanning your statement too, you didn't do badly in terms of the budget. I mean, to have an increase of over $16 million over last year, I'm curious about whether or not there were some requests that you made with OMB that were not recognized or included, or did you get everything you wanted.

Mr. RODNEY. That was my first ability to impact the budget, and that was the number I requested.

Mrs. MORELLA. And you got it?

Mr. RODNEY. Yes.

Mrs. MORELLA. That's a lot of money. I mean, it's—I believe what you are doing is primary to everything in the whole space program. Nobody does that. Are you however, a little bit concerned that you may be adding to a bureaucracy, proliferation with communication and all that, and not really getting to the heart of the problem which was addressed by this committee's analysis of the Rogers Report in terms of communication. There was not—if there was an

abundance of communication that was—nobody was reading it or listening to it.

Mr. RODNEY. That is true, and I spent most of my life on the other side of the fence, and I'm not interested in creating more bureaucracy, and I am sensitive to that. However, we do need to get a more rigidized or more organized system going, not for the first or the second flight. I'm not really concerned.

There will be such a high level of interest on the first flights, that the adrenalin will be flowing so high that you won't have anything fall through the cracks. But what we have to point to, and what my systems are pointing to, are the 10th through the 20th launches, when again people may start getting relaxed, and that is what we have to point to.

Mrs. MORELLA. Did you consider taking people from some other divisions to address, you know, your new department, in terms of allocation of funds or requests—budgetary requests? I mean, I'm just wondering if we are using our money to best—the taxpayers' money to best advantage. It seems to me you might have been able to take some resources from another area, human also. Or did you—maybe you didn't even bother with that?

Mr. RODNEY. Well, to be perfectly frank, Mrs. Morella, I don't think I was smart enough to even work such an issue at this point in time. I've only been with the Government for relatively few months, and I'm not trying to evade your question. I'm really not smart enough to answer it, to tell you the truth.

Mrs. MORELLA. I mean, we just—we look at—we look at the increase in the budget. You know, now the magic wand has been waved, and all of a sudden we'll not have the problems we had before, and I guess what I am saying is it isn't always the money—is not always what accomplishes it. It's the plan that is geared to work and is highly cost effective and efficient and I would like to reflect the fact that I and probably my colleagues would like to make sure that we get the most for the kind of money in the budget.

Mr. RODNEY. Well, I will assure you that I am going to do everything in my power to make the maximum utilization out of those dollars, because we have a tremendous challenge ahead of us, and we're going to need to make maximum use out of those dollars.

Mrs. MORELLA. If—I don't know really how you do it with OMB. Are you prepared if they do not accept your first request to make cuts? I mean, like, do you have a second level of requests that you make, and then maybe a third, and in terms of your priorities, if you had to cut, where would you cut?

Mr. RODNEY. On this particular budget, I have not gotten that well organized. Now I am trying to get organized for the 1989 budget operation that I will have a much better understanding of what my potential requirements are, and have a better posture to have fall back positions. If I had to start fighting for this budget, I would work it on an ongoing basis, to be perfectly frank with you.

Mrs. MORELLA. I guess you are bringing a refreshing naivete as well as experience to the job.

Mr. RODNEY. Right.

Mrs. MORELLA. Just one final thing, as somebody who has taught English. I'm always amused by this language that I see. I mean, I

don't know whether to call it nonspeak or what, but I mean, now that we've got, let's see, reliability, maintainability, quality assurance, et cetera. How about the maintainability, I bet you couldn't find it in the dictionary, but it's——

Mr. RODNEY. Well, that's the reason it costs so much to repair your automobile. A lot of them don't have maintainability built into them, incidentally, it is not new. Why it was added to my title—it has always been a function in the so called NHB 5300 which is a NASA document that outlines all of these isms. It is really called safety, reliability, maintainability and quality assurance. You need a large set of lungs to say all that, but the maintainability has always been there.

There does need to be a much greater emphasis by NASA. Well, it's had very little emphasis, almost none, and it has cost us on the Shuttle. You've heard about the spare parts problems and things of this nature. Well, that's an offshoot of maintainability or lack thereof.

And with a Space Station, we need to really emphasize maintainability because when you get up there, and you want to hang something up, and you don't have the right bolt, it's a long way to the corner hardware store, and so maintainability is doing a very thorough analysis to make sure you can repair and maintain something under the circumstances that you're operating in.

Mrs. MORELLA. We're going to reach the point given—by the turn of the century, where we're not going to be able to communicate with each other anymore. And we're going to be using hand signs or something.

Mr. Chairman, what I—what I'm interested in and curious about is when we look at budgets, or when they ask for their budgets, is there a way that we could also find out from all of them how they would cut if they had to cut? See what I'm getting at? I mean if they are initially—just so that we have some guidelines. Not that we would necessarily cut them, but just so we would know what their priorities are.

Thank you. Thank you very much, Mr. Rodney.

Mr. RODNEY. Thank you, Mrs. Morella.

Mr. NELSON. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

First of all, you give me a little uneasiness when you say you're not smart enough to do this or that. You've been selected because you're smart enough to do the job. And you may not be up to speed on everything——

Mr. RODNEY. Right.

Mr. PACKARD. And that we can understand, but we will not excuse you for not being smart enough.

Mr. RODNEY. Okay, thank you.

Mr. PACKARD. The—I'm a little hazy still about what specifics we're doing in terms of safety, communications, and some of the recommendations or the concerns that came out of the Commission report. Are you at a position yet where you could outline specific changes that are being made within your job description that will prevent the problems that existed at the time of the *Challenger* accident?

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Mr. RODNEY. Well the entire gist of my formal statement outlines a lot of the actions, all of which are really built around the thought that we are creating a system that will prevent another *Challenger* accident. And what we're trying to do is emphasize both existing techniques that we know have worked and developing a few new ones to augment those and get them formally in place. However, the key issue is still people and communications.

Mr. PACKARD. Now I gathered from your answer to Ms. Morella's question that budget constraints, or lack of—lack of funds to do what you are charged to do to develop a system that will not repeat what we've experienced?

That's not the problem. That's not a stumbling block. You've essentially gotten all the funds that you—or will get all the funds that you're requesting to do what you're charged to do in order to provide a safety and communications system that will not duplicate the problem.

Would you be able to do this for me, and perhaps the committee? Would you review the recommendations, specific recommendations, found in the Rogers Commission's Report and list those—and list along a side by side what has been done, or what is being done, or projected to be done, in terms of the—the specific recommendations that relate to safety, communications and the new structure that falls within your jurisdiction. Could you do that for us?

Mr. RODNEY. Yes.

Mr. PACKARD. So that we would be able to see where we're at, our progress toward the reorganization that's been mandated.

Mr. RODNEY. That's a very fair request.

Mr. PACKARD. I think it's important that we know how we're moving, and I'd like to also, if you could include with that, a timetable as to when you expect the—those that are not yet addressed, or not yet completed would be finished. If we are going to launch at a specific date, which we may or may not be able to achieve, but if we're going to launch shortly after the first of the year, I would be very interested to know how we're progressing in terms of the infrastructure, organizationally, to complement that launch date.

Mr. RODNEY. We'll furnish it.

Mr. PACKARD. And that's all I would ask, Mr. Chairman.

[The information referred to above follows:]

(chart)

Material requested for the record on page 51, line 1187, by Chrm. Nelson during the March 18, 1987, hearing.

Commission Recommendations/Actions

| | | |
|---|---|---|
| 1. | Solid Rocket Motor (SRM) Design Independent | SRM redesigned, NRC Oversight Panel is in operation. Preliminary Design Review completed November 1986. Critical Design Review scheduled for August 1987. Design Certification Review to be held in December 1987. |
| 2. | Shuttle Management Structure | Reorganized under Admiral Truly, Shuttle Program Management moved to Headquarters. Key position changes made. |
| | Astronauts in Management | Crippen Study initiated in June 1986. Astronauts placed in key positions. (See attachment) |
| | Shuttle Safety Panel | Space Flight Safety Panel formed and chaired by Astronaut Bryan O'Connor. Report to Associate Administrator for SRM&QA. |
| 3. | Criticality and Hazard Analysis | All waivers cancelled. FMEA/CIL (Failure Mode and Effects Analysis and Critical Items List) for all systems are under review. An independent National Research Council (NRC) Audit Panel was appointed in July 1986 to oversee FMEA/CIL reviews. NASA Headquarters review is ongoing. |
| 4. | Safety Organization | New Associate Administrator position and Office of Safety, Reliability, Maintainability and Quality Assurance created. Headed by George Rodney, appointed July 8, 1986. Reports directly to NASA Administrator. Responsibility definitions and plans are in place. Includes Trend Analysis Programs. Resource Assessment and interface with the Safety Panel. MSFC and KSC have consolidated reliability and quality assurance functions under a Director of SRM&QA. Policies are in development for PCT* and monthly significant problem reports are now being submitted by the Centers. Data bases to support the PCT effort are being established. |

| | | |
|---|---|---|
| 5. | Improved Communications | Crippen study initiated in June 1986. Recommendations to OSF in October 1986. Implementation now in progress. The Director, Shuttle Projects Office, at MSFC has been designated a Headquarters employee, reporting to the Deputy Director, NSTS Program. MSFC has the following new managers: Center Director; Director of Shuttle Projects; Solid Rocket Booster Projects Manager; Director of SRM&QA and Director of Science and Engineering. |
| 6. | Landing Safety | Committee chaired by Astronaut Bryan O'Connor. Conducting reviews and tests of landing safety and brake systems. Tests have been completed on load reductions, gear skid, wheel spin up, rim roll, weight tow, Stiffend Axles. Drag chute tests, tire models and landing test are under way. |
| 7. | Launch Abort and Crew Escape | All bailout options were considered. Zeroing in on side hatch extractions using tractor rocket system. Potential for recommended bailout system to be installed by early 1988. Goal is to meet first flight in 1988. |
| 8. | Flight Rate | Flight rate working groups and the NRC have made assessments on flight rates with a four orbiter fleet. Space commercialization has been cancelled. Payload manifesting of major payloads is completed. An annual flight of 15-16 flights per year can be safely sustained by 1993 with proper budget and manpower. |
| 9. | Maintenance Safeguards | Maintenance safeguard teams are in place. All OMI's** and OMRSD's*** are being reviewed. The reviews will be completed by August 1987. The NSTS System Integrity Assurance Program Plan has been baselined. Implementation of the plan will be in effect by first flight. |

* Problem Reporting, Corective Action and Trend Analysis
** Operation Management Instruction
*** Operation Management Requirements Systems Document

Mr. HEFLEY [presiding]. Mr. Nelson left the room and handed me the gavel. I can't tell you how flushed with power I am, unaccustomed to this. [Laughter.]

I hope somebody will do something I can rule them out of order for. And I think Mr. Buechner is up to the task, so, Mr. Buechner, you're next.

Mr. BUECHNER. I hope that the acting chairman doesn't get confused that a gavel is not the same thing as a majority.

Mr. Rodney, we all know that the most frequent criticism of the *Challenger* accident was the pressure to meet the launch schedule, a schedule which, as you know, but we all need to remind ourselves up here, that the flight rate was endorsed by Congress.

What I'm wondering is, that realistically, with all the safety precautions, regardless of their cost, that we are going to have proposed and hopefully will implement, we still are living in an age in which accidents do happen, and you're not in any way saying that by implementing any of these suggestions, that we are going to have a fault-free space program; is that right?

Mr. RODNEY. That is correct. We are in a high technology business, and there is an element of risk with it, and we all must recognize that.

Mr. BUECHNER. And one of the things that I think it's important for us to reiterate is that we are woefully behind in putting up the various hardware, scientific experiments that this country had programmed over a long period of time, and we will have to catch up; is that correct?

Mr. RODNEY. That is correct.

Mr. BUECHNER. And I happened to read in today's Christian Science Monitor that the Russians, because of the export embargo on high tech information and gear, that they are not being able to get the contracts signed that they want to with other countries; is that correct?

Mr. RODNEY. I'm not aware of that. I can't answer that.

Mr. BUECHNER. Well, at least that's what they said. They're blaming it on us. We won't give them the things necessary, so that they can go out and get some hard currency, which is kind of an interesting little twist on the results of our denial of the high tech exports.

Mr. RODNEY. That is interesting.

Mr. BUECHNER. I guess my point is that I want you to make perfectly clear to us that we are living in a real world. Accidents do happen, that this committee cannot have its cake and eat it, too. It cannot simply say that we must be the leaders in space, and we will implement all of these safety technology, but then nothing will ever go wrong again, because I think that's a realistic response; wouldn't you say that's correct?

Mr. RODNEY. You are very realistic. That is an excellent statement.

Mr. BUECHNER. Well, I notice that the acting chairman left the room, so I guess he didn't rule me out of order on that.

That's really all—I've got one other thing. Can you give me an estimate of what you think, based on the current state of affairs, what the launch pressure will be, once we get the program all back

on line? I mean, are we going to right back in this same trick bag, so to speak, of launch pressure?

Mr. RODNEY. I believe there has been developed enough of an awareness of this issue that it will not become as great a problem as it apparently was in the past. I think all levels of management and the oversight functions that are existing have made a great deal more consciousness of this issue.

However, it is a real issue. It's one that we have got to stay alert to. And I have a specific charter to monitor the situation and to bring it to a head if, in my judgment, I feel that schedule pressure is becoming significant to the overall potential safety.

Mr. BUECHNER. One final question, and that is: Do you see any need for expanded competition in bidding for some of the components, such as a second source for the rocket system? Is that part of something that you would be encouraging to have more—I don't want to say "maintainability," because that wouldn't be applicable, but is there something you see in your agenda that would ask for more competition, that would in any way ensure a better quality?

Is that a necessary element in better quality, is to have more competition?

Mr. RODNEY. No, sir. I wouldn't believe that that is a significant factor. At least, I wouldn't spend my time working that as an issue. I don't believe I would gain that much by having competition for safety. Now you have the argument on cost, I don't believe that it's significant on safety.

Mr. BUECHNER. Thank you, sir.

Mr. NELSON [presiding]. At present, Mr. Rodney, we understand that Qualification Motor 8 testfiring is not planned before the next launch of the shuttle. That is a warm-weather test.

What is your personal opinion about that?

Mr. RODNEY. That is a decision I am still monitoring. It depends very much on how successful the other testfirings are. If we start having any anomalies out of those, then I am going to be very much in the position of requiring that as an element before the next firing.

Mr. NELSON. And if there are no anomalies?

Mr. RODNEY. If there are no anomalies, I am still open on that issue. I really am examining that.

Mr. NELSON. For what reason?

Mr. RODNEY. Well, basically confidence level, whether the firings we have scheduled now will give us sufficient confidence level, and I am still weighing that decision, quite frankly.

Mr. NELSON. Confidence in what regard?

Mr. RODNEY. Just in the basis that we have developed a reasonable confidence level that the first flight and subsequent flights will be safe.

Mr. NELSON. There will be those in the agency that will argue, "We don't need the warm-weather testing, because the problem was in the cold weather."

Mr. RODNEY. I recognize that.

Mr. NELSON. What will be your response to that?

Mr. RODNEY. Well, as I say, I'm still weighing that, because there are a variety of factors there. One is whether we have tested it in the warm condition.

Mr. NELSON. Have we?

Mr. RODNEY. Well, I don't know. See, it depends on what the weather conditions are when we do our other firings. That's a vagary of the weather at Utah. We're a slave to that.

Mr. NELSON. Ms. Morella was asking you about maintainability. Let me just offer an editorial comment that you need to be careful that you don't get yourself into a position where you become responsible for the operational performance vis-a-vis maintainability, as opposed to your role of being an objective observer of that performance and that maintainability.

Mr. RODNEY. I recognize that as good advice, Mr. Chairman.

Mr. NELSON. How many new people have been approved to work in safety areas that were not working on them before the accident?

Mr. RODNEY. The specifics in safety, I'm not sure we have a ready answer for that. I may have to provide that to you. I don't believe I can give you an off-the-cuff answer on safety. I can give it to you before the day is over.

Mr. NELSON. Okay, please do that.

[Information to be furnished follows:]

By the end of FY 1988, Safety, Reliability, Maintainability and Quality Assurance civil service manpower will increase by 310 from the FY 1986 baseline. This represents a 37.2-percent increase.

Mr. NELSON. Are there any other—and when you provide that, we want to know your personal opinion about whether or not that number of new people in safety are adequate or whether or not you need additional people.

Mr. RODNEY. Well, we are still building up, quite frankly. I will give you those numbers also, but we are still in a buildup posture. In other words, we have not reached the level we anticipate.

Mr. NELSON. I'm talking about when you get to that level. When will that level—when are you going to get to that level?

Mr. RODNEY. Well, we're targeting to get to our operating level at the end of fiscal year 1988.*

Mr. NELSON. Okay. And how many new people will be on your team for safety at that point?

Mr. RODNEY. I will provide that number to you.

Mr. NELSON. Well, do you have a ballpark right now?

Mr. RODNEY. Oh, well, yes. You mean at headquarters or total?

Mr. NELSON. I'm talking about total.

Mr. RODNEY. No, I don't have that ballpark number.

Mr. NELSON. All right. I think the gentleman there does.

Mr. RODNEY. Are you talking the whole safety and quality as a whole organization?

Mr. NELSON. Yes, sir.

Mr. RODNEY. Well, we will have about a 37-percent increase.

Mr. NELSON. Okay. How many bodies is that?

Mr. RODNEY. That is some 300 bodies as Civil Service.

Mr. NELSON. And that's the end of fiscal year 1988?

Mr. RODNEY. Yes, sir.

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* See appendix, p. 1199.

Mr. NELSON. All right. Now my question to you, since you are the head of this whole operation, is it your personal opinion that that's enough for you?

Mr. RODNEY. We are still working on that issue, but right now I believe it is sufficient, yes.

Mr. NELSON. All right. Now are there any other aspects of the shuttle recovery that you have concerns about besides what we were talking about, this QM-8 testfire?

Mr. RODNEY. Well, obviously my whole job revolves around concerns, unfortunately. The ones that we all know about, we're working diligently.

If I had a new concern, it would be whether, in fact, in the mass of data that is sitting around, whether we have something that we're not working that we should be working. And what I am doing in that regard is that I am looking at all the concerns that have been voiced by the astronaut group, by flight operations groups, by NRC, by ASAP, and by the congressional committees, the Fuqua Report and what have you, and we are taking a hard look at whether the changes that we have in progress, hardware changes and procedural changes adequately cope with those concerns, and if not, should we be doing something about them. So I do have that process in work.

Mr. NELSON. One of the things we understand you're doing is, you're developing a set of indicators to try to help you gauge whether or not there is launch pressure. Tell us about that.

Mr. RODNEY. Well, number one, to be perfectly frank, the primary gauge is going to be a judgment call. However, in order to support my position, I am coming up with a series of 8 to 10 indicators of things like OMI slips.

Mr. NELSON. What is that?

Mr. RODNEY. Where procedures at the Cape which were scheduled for today have slipped for 2 weeks, how many of those slippages occur, how many mod kits have slipped, how many engineering changes are delayed, things of this nature, which are all indications of the fact that as you get closer and closer to launch, there's a bigger buildup of activities that are on schedule or haven't been adequately scheduled, and that's the kind of barometer that I'll be looking at to help reinforce my position. So when I go in and say, "The schedule pressure is becoming intolerable," I'll have some concrete backup to help reinforce my position.

Mr. NELSON. Is overtime one of those indicators?

Mr. RODNEY. Yes, sir. Overtime is one of them.

Mr. NELSON. All right. Now, you know, one of the scenarios is that NASA goes to 16 flights a year with the shuttle in the not too distant future. And if there is the attempt at eliminating overtime or reducing it substantially or changing it drastically from what used to be the case, that is going to mean the hiring of additional personnel; is that not?

Mr. RODNEY. I would assume that will be the net result.

Mr. NELSON. Is that cranked in to Dr. Fletcher's budgetary considerations for the next 5 years?

Mr. RODNEY. Quite frankly, I'm not smart enough to answer that.

Mr. NELSON. Then I think that you ought to ask that question. We are certainly going to ask that question. But you need to be asking that question, too, because it directly involves safety and reliability.

Mr. RODNEY. Yes, sir, it does.

Mr. NELSON. Otherwise you get yourself right back into that budgetary pressure.

Mr. RODNEY. Uh-huh.

Mr. NELSON. And, of course, you know overtime was one of the concerns of the Rogers Commission.

Mr. RODNEY. Right.

Mr. NELSON. All right. Now, having said all of this, I want to know what are you doing to make sure that you don't overreact on safety, and get everybody all tangled up in a maze of paperwork, so that we can never launch?

Mr. RODNEY. That is an excellent observation. It is an issue that we have to be very careful of. It's very easy to hide behind a mountain of paper and say that you're not ready to launch. We deal in a risk assessment world where we have to assess the risk and make a decision. And it is one of my jobs and one of my responsibilities to make sure that that overreaction does not occur, and to make sure that we do end up with a viable system of checks and balances. And it is like, many people say, well, are you going to stop a launch? Well, except for the time sense of things like the ice issue, if I ever had to stand up and say we can't launch at a launch readiness review because of a long-term technical problem, I would be at failure as well as the rest of the system, because I should get the item fixed beforehand. I shouldn't have to stand up at the last minute and try to stop the railroad.

Mr. NELSON. Okay. You—certainly.

Mr. BUECHNER. Just to amplify the Chairman's remarks, I think that its been evident at the various hearings we've had that NASA as an entity has suffered a severe lack of orientation. And I think it's true, it's a direct result of the catastrophe.

And I think what the Chairman is pointing out, and we want to emphasize is that, in our haste to beat our breast and wear our hair shirt and, you know, cover our head with ashes, that we've done our period of mourning, which was deserved, and we're trying to implement things which will make us stronger and safer in the future. But it's really imperative that every part of NASA get rid of this, other than to reflect upon it, but not have it be the steering force as they go forward.

And it's important for you to know that we want to be safe, but we also want to be venturesome and go forward. And I've seen this kind of categorical guilt, it seems to have flown—flowed into every segment of NASA as they've come before us. And it's really kind of disconcerting to me as a freshman member.

That was a political statement, it really didn't deserve any response, I think, Mr. Chairman. I just wanted to emphasize your remarks, I think they're right on target.

Mr. NELSON. Okay. I want the record to show that my conclusion of your answer is that you have not answered the question. And I'm not sure that you can. But I think that you ought to be able to in the future. It's one thing for you to say, that I'm not going to let

excessive paperwork happen, that's going to hamper the can do spirit, if you will, of this agency of the ability to launch and so on and so on.

It's one thing for you to say that, when in fact, you've got to delegate a lot of that to the 300 plus new people that are working on this. And I'm going to digress for just a minute and give you an example of the ultimate and ridiculousness about paperwork. And to say that this will never happen to you is to be foolish. Because if this can happen, it can happen to anybody.

Do you remember an organization called OSHA, the Occupational Safety and Health Administration?

Mr. RODNEY. I'm very familiar with it.

Mr. NELSON. A noble purpose. I had a constituent of mine, back when I was a freshman Congressman, 9 years ago, that came to me, and this was an honest to goodness true case. You know, the OSHA inspectors would go in and they would look at a plant and they would rate a particular person, particular company, and they would note the defects. And then, the person for Occupational Safety and Health would have to correct the defects. This particular—and if they had defects, they had to correct them; if they didn't correct them they got penalized in some way.

Well, this particular company had zero defects. But OSHA came back and fined the company because they did not post a notice that they had zero defects. People get so narrowly focused in their paperwork that they lose sight of reality in the big picture.

Now, you've got to be careful in your operation. And yet, you've got a tremendous responsibility on your shoulders.

Mr. Volkmer.

Mr. VOLKMER. Thank you, Mr. Chairman, I just have several questions and concerns that I'd like to ask.

I notice that several times in your statement you refer to cannibalization in trying to get a hand on cannibalization as it affects safety, a part. To me, that's admitting that cannibalization will continue; is that what we're looking at?

Mr. RODNEY. Well, unfortunately, having been in this business a long time, and I'm a realist, yes, you would never fully eliminate it. The agency has taken major steps to alleviate it, to spares position, the spares situation looks very good right now, and they're moving along in a very good line. But to say that you ever eliminate it totally, no.

Mr. VOLKMER. All right. Now, let's assume that this is not the year 1987, this is the year 1989, and in 1988 in late March we had our first launch and we've had since then five or six successful launches, but we're now preparing for a launch in May, and we're out there cannibalizing, taking off of one and putting on the other, we've only got three to work with. Do we look at that in a safety requirement as per each individual type of item that is being transferred from one vehicle to another, and therefore, will have to be replaced or are we just looking at them to make sure that it's done, that it is replaced?

Mr. RODNEY. Well, the safety implication of the cannibalization is really the thought of the sheer act of removing and replacing, you expose yourself to damage in the areas that you're working,

and the potential of damage where you're transporting the item back and forth between the vehicles and what have you.

So, cannibalization, the individual acts can be controlled. The thought is, if it gets to be too big a problem, you're just exposing yourself to a needless risk.

Mr. VOLKMER. Well, I'm assuming that we may get ourselves into the same thing we were in before the *Challenger* accident; and we were cannibalization very extensively at that time to the point, in my opinion, that if we hadn't had the *Challenger* accident we wouldn't have been able to fulfill 86 launches anyway.

Mr. RODNEY. That is probably correct.

Mr. VOLKMER. The time frame. And what I'm asking you is, how do you view the safety features or the requirements for safety that you're going to have to review in the cannibalization area?

Mr. RODNEY. Well——

Mr. VOLKMER. Are we going to have to have people monitoring every part, et cetera, that is being changed to determine whether or not that creates too much risk?

Mr. RODNEY. This is done in a normal cannibalization, you will review the risk of making it. And when you make the decision to go in and cannibalize that is, and should be, part of the decision.

Mr. VOLKMER. Who is doing that?

Mr. RODNEY. That is done by both engineering and the quality people assigned.

Mr. VOLKMER. So, your people will be doing that?

Mr. RODNEY. Yes, sir. They will be involved.

Mr. VOLKMER. The other question I have has to do with something completely different. As I look back and reflect, as many of us have, on the *Challenger* accident, maybe I'm trying to simplify it a little too much, but to me I think part of the problem was when the Morton Thiokol engineers came up with, "Hey, I don't think we should be launching at this time because of the ice, et cetera." And they brought that up at Thiokol, and then went to Marshall, and in my opinion, Marshall said, "Well, can you prove to us, you got the data to prove to us that we can't launch." Instead of saying, "Have we got the data to prove that we can launch." That's a mindset.

What are we doing in quality control to correct that mindset?

Mr. RODNEY. Well, that is what we-have been revitalizing the operation, bringing in new people, new leaders. We brought in new leaders at each of the Man Flight Centers; and part of that is to help improve that mindset.

We also have new Center directors, and they are primarily working that mindset. And now, I can tell you from firsthand experience that I know J.R. Thompson is working that issue at Marshall.

Mr. VOLKMER. Well, if we have a, whether it's a contractor engineer or whether your own quality control people, if they come up with something that's unforeseen that's occurring at a launch in the future, and they bring it up, the idea won't be, "You prove to us that it won't work." We aren't going to see that anymore.

Mr. RODNEY. That is our intent all through the organization.

Mr. VOLKMER. Will they be able to go to somebody other than a Center director; where would they go? Will they go through you?

Mr. RODNEY. They can come through us, yes. If they don't feel that they're getting a fair shake through the normal channels, they can come through us.

Mr. VOLKMER. Now, remember we're 15 minutes before launch time, and the countdown is going, what can you do about it?

Mr. RODNEY. What can I do? If I am convinced that we have to abort the launch, I can tell the Administrator that we have to abort the launch.

Mr. VOLKMER. You have to review whatever is going on down there. If you feel that it has to be reviewed, you'd have the authority to go to the Administrator then and request abort?

Mr. RODNEY. Yes, sir.

Mr. VOLKMER. Okay. Thank you very much, Mr. Chairman.

Mr. NELSON. Mr. Rodney, you have a tough job. It is a tough job, and I want you to know you have the full support of this committee.

Mr. RODNEY. I appreciate that.

Mr. NELSON. One of the tough things is going to be not getting your people to say whoa, stop, but the opposite, to getting a conclusion that is unanimous that says we are safe enough to fly, when in fact you consider that you have got a system that is inherently risky.

Mr. RODNEY. That is correct.

Mr. NELSON. Now, that is a big set of boots that you are going to have to fill in that job.

Mr. RODNEY. Yes, sir. I appreciate that statement. It is very, very true.

Mr. NELSON. Are there any other questions of Dr. Colladay or Mr. Rodney?

[No response.]

Mr. NELSON. We will look forward to visiting with you in the future.

The meeting is adjourned.

[Whereupon, at 12:03 p.m. the meeting was concluded.]

# 1988 NASA AUTHORIZATION

THURSDAY, MARCH 19, 1987

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY, SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND THE SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS,

*Washington, DC.*

The subcommittees jointly met, pursuant to notice, at 2:14 p.m., in Room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the Subcommittee on Space Science and Applications) and Hon. Dave McCurdy (chairman of the Subcommittee on Transportation, Aviation and Materials) presiding.

Mr. NELSON. Good afternoon. We have been having a series of hearings on the fiscal 1988 budget. Today, we are going to receive testimony from the Deputy Associate Administrator for the Office of Management, the Director of Facilities Engineering, and the Office of General Counsel. We are especially delighted to have our colleague, Wes Watkins, here on the subject of technology transfer.

It has been 14 months since the Challenger accident and there is still so much to be done. NASA has started to take the first important steps in trying to regain our position of preeminence in space. Right now, in the next several weeks, are going to be some critical times because how we craft together this authorization bill and how we handle the intricacies of the budget process, which is ongoing at this very moment that we speak, and how all of this shakes out, is going to have a major impact on America's space program.

Now today we are going to consider the request from the Office of Management. This certainly is an important area because it covers one of NASA's most important resources and that is its people, those scientists, those engineers, those supporting personnel, who make these fantastic space missions possible.

The Committee has long concurred that this is a very vital asset for the nation's space program, that it is the collective experience and the intellect of this personnel core that has enabled us to do the extraordinary things we have done and it is so important that we hold this team together as we try to do what we are going to do in the future, and yet we see in front of our eyes that it is being depleted.

This is partly due to a rapidly aging workforce and the inevitability of large scale retirements in the near term. It is also due to the apparent inability of NASA to compete financially with industry in a marketplace that pays a lot more than does Government service.

So we are going to be interested in hearing from Dr. Robins on NASA's plans to combat these problems.

Then we have General McGarvey, who is the Director of Facilities, to testify about the 1988 request on the construction and repair facilities.

Mr. Frankle, the Deputy General Counsel, is here to give us the details on any legal changes that NASA wishes to include in its authorization.

We all want to join together to welcome our colleague, Mr. Watkins, who wants to share with us his thoughts on technology transfer.

I would like to turn to Bob Walker for any statement that he might wish to make.

Mr. WALKER. Thank you, Mr. Chairman. I don't really have an opening statement except to concur in what you had to say early in your statement about the need to understand that we have an ongoing situation right now in the budget process which could dramatically affect the ability of this nation to compete in space.

I would hope that we are going to be able to resolve that in a way that does allow us to move forward and look to our future with a great deal of hope and anticipation, because the President, it seems to me, has submitted a budget which is the minimum necessary to carry this program forward into the future and because we are concerned about the nature of our budget crisis, we probably are going to try to live within that budget, but it certainly is the minimum necessary to project the programs that the Space Agency and the other developmental agencies of our Government need in order to address the future.

I think that within the budget process here and within our authorization process, we should try to live within those numbers. We should not necessarily feel ourselves bound by the priorities that are within that budget, but in terms of the overall commitment to this nation's future, those figures are the minimum necessary to make NASA whole in the near term and in the far term.

Mr. NELSON. Okay. I appreciate that. We are especially honored in that this is a joint hearing with our Subcommittee on Space and the Transportation, Aviation and Materials Subcommittee, which handles all of the authorization with regard to the first "A" in NASA, the aviation part of NASA. Naturally, these items that are before us today in the institutional issues involve both A's of NASA.

We are honored to have the Chairman of that Subcommittee, the gentleman from Oklahoma, Mr. McCurdy, and his ranking member, Mr. Lewis. Let me turn first to Mr. McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman. We are pleased to join with our colleagues from the Space Subcommittee today to consider items in the NASA program for fiscal year 1988 and beyond that are of mutual interest.

One issue that I am interested in specifically is the condition of NASA's aeronautical facilities. Many of these are quite old, having been built in the 1940's. Furthermore, because NASA has invested very modest amounts in rehabilitation and modernization over the years, some of these facilities are reaching a point where major capital investments will be needed to restore them.

I will be interested in learning how extensive NASA thinks the problem has become and what plans it is making to restore these important national assets.

I would also like to extend my welcome, Mr. Chairman, to my colleague from Oklahoma, Mr. Watkins, who represents the Third District which is my neighbor to the south and east from my district. We border, about a 110 mile stretch of Oklahoma together, and certainly he is a very capable member of as we say powerful Appropriations Committee. We don't just say Appropriations Committee, the powerful Appropriations Committee. We are pleased that he is here today. I'm sure we have mutual concerns with him and hopefully he will take the message back to the powerful Appropriations Committee that we could use some help in our authorizations.

I appreciate the opportunity to join in this hearing today.

Mr. NELSON. Thank you. Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman. I would also like to say it is a pleasure to be with you today. The technology developed by NASA and transferred to the aeronautics community has played a significant role in keeping the United States industry in the forefront worldwide.

For example, the aerospace trade surplus in 1986 was almost $12 billion. It was the highest of all United States export sectors, which is refreshing. In order to conduct research and development for the aeronautics technology, the proper facilities are absolutely necessary.

Testimony before the Transportation Subcommittee this year has pointed out an alarming situation. Many NASA facilities, as my Chairman has pointed out, and especially wind tunnels, are very old and in need of improvements. My own survey at Langley facilities serves to illustrate the point. The 30 x 60 wind tunnel is over 50 years old. Five tunnels are between 40 and 50 years old and five between 30 and 40 years old.

I'm not implying they are all in a state of disrepair, but these facilities—and quite frankly they often require extensive remodeling and updating and in doing so, you have a high frequency of repair.

The 12 foot pressure tunnel at NASA Ames will serve as one example. It was built in 1946 and has been used to test essentially every major type of aircraft flying today. During a recent inspection of 10 miles of wells in this facility, many cracks were found. One crack was 114 inches long and penetrated 80 percent of the steel's thickness. This was a disaster waiting to happen and NASA's diligence in examining the facility brought the situation to light. Nevertheless, it may require up to $60 million just to repair this particular tunnel.

This is an issue that must be addressed and the sooner the better for both NASA and for the aviation industry.

Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Lewis. Mr. Watkins?

## STATEMENT OF HON. WES WATKINS, A REPRESENTATIVE IN CONGRESS FROM THE THIRD DISTRICT IN THE STATE OF OKLAHOMA

Mr. WATKINS. Members of the committee, I want to say a special thanks for allowing me to come back to the committee. I've kind of looked around, Mr. Walker, I believe you are the only member remaining on this subcommittee when you and I were on it together. So, let me say this, I'm delighted to be back. I'm delighted to be back because of a very strong interest that I have, and I'd like to share it. And, Mr. Chairman, I have a written testimony, and if it's all right I'd like to make that part of the record, and also have the opportunity to revise and extend my remarks because I've got some additional things I'd like to say.

Mr. NELSON. Of course.

Mr. WATKINS. For members of the committee, and let me say I'm glad to see my good colleague from Oklahoma here, and I know some of the things I'm going to reflect on, he's well aware of. But, you know, if there's one person in the Congress that would have been considered the Founding Father of the Space Program, it would have been Robert S. Kerr from Oklahoma. The late Senator Bobby did as much, if not more than anyone in going to probe the outer areas of space and around this great planet we know.

In fact, he was so strongly—felt so strongly about it he made his very personal friend an assistant, James Webb, the first administrator of NASA.

Now, the other thing I'd like to point out that, the area of technology utilization, which I think is so important, the fellow that was the first director of it, if that was the title, was a fellow named Bren Curr, Robert S. Curr's son, that had the insight to start working with the technologies as it was being developed from the tremendous mandate that we had, to have a fast paced, fast tracked funding of NASA.

I might say, I became very interested in this when a small utilization program was put together with Southeastern State University. I actually went there and spent untotalled hours digging into data to help write an economic development plan for the Southeastern part of the State of Oklahoma. That's one of the reasons, when I came to Congress, I sought membership on this Committee of Science and Tech, and the Subcommittee dealing with Space Sciences, because I could foresee, if we would make better utilization of the technology that's developed from a space program, that would enhance not only the people's feeling of wanting to make a greater investment, but bring that development back into a more practical application.

If you reflect with me, if you'll think with me, the only federal agency that has done a yeoman's job, a tremendous job in transferring technology has been Agriculture. And Agriculture, which happens to be my major field of study, we were taught how to produce, maybe we got overproduction, but it's a lot better to be overproduced than not have that production.

But I have to say to you, the only other federal agency that has seen the wisdom of trying to work out a technology transferred dissemination program has been NASA. And we've done, I'd say, a

good job, but I want to keep encouraging the subcommittee to keep this out front to make sure that we do continue to build that kind of support for the space program, and we do make it so it can be workable and usable and beneficial to the taxpayers of this country. I think that makes them feel good.

There are a lot of good inventions that come down the pike that helps human kind, helps people around the world. I'd like to say, from our efforts and from our efforts of working with the Rural Application team, we've been able to assist a number of people throughout Oklahoma and in the edge of Texas, which happens to be their area, get some technology, not only disseminated, but transferred in order to assist small businesses and industries, also, some professional groups that had certain needs.

I'm very proud to report to this committee, as my good colleague from Oklahoma Dave McCurdy knows, our economic conditions in Oklahoma are not the greatest at this time, and we're looking at every way possible how to increase some economic opportunities for our people, through their efforts, through some industrial innovation center, working with several areas of potential technology that could be licensed by NASA.

Today, in Oklahoma, one of those technologies has been licensed and is becoming a business and an industrial incubator that will produce jobs in some of the economically depressed areas.

Now, that's what the role I think should really be. That's the way I think that we should look at our technology and say, how can it be applicable to be a business, an industry through new product development or new process development, and also, to build those jobs which are so vitally needed for all of America, and also, very much in the State of Oklahoma and many of the areas like Louisiana, Mr. Hayes, and others, we need all the help we can get.

So, let me say, I wanted to come and report to you that some good things are happening. I want to encourage you to make sure those investments are made in technology transfer that will allow us to help build new business and industry. I'm the author of Chapter 11 of the Stevus and Wilder Act, which is attempting to get, Bob, as you recall, when we enacted that back some years ago on our committee, which is trying to get more of some of the dollars for research set there to work on technology transfer.

We haven't done the best of job in getting our research into a technology transfer mode. I think it behooves us all to try to do that, especially at times when we have a low amount of dollars we can work with, and I think our taxpayers appreciate that very much.

So, I will say, thank you for letting me come by. I want to ask you for your continued support for the Rural Application team that are helping a lot of people in rural areas, not only in Oklahoma, but in Texas and through other areas, other application teams. But I think what you're all about, all of you, in trying to bring forth technology transfer is vitally needed.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Watkins follows:]

STATEMENT OF

THE HONORABLE WES WATKINS

3RD DISTRICT, OKLAHOMA

ON

TECHNOLOGY UTILIZATION

BEFORE THE

SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE,

SPACE SCIENCE AND APPLICATIONS SUBCOMMITTEE

MARCH 19, 1987

Mr. Chairman and members of the subcommittee, thank you for allowing me to appear before you today.

I come before you, as I have each year since I served on the Science and Technology Committee, to express to you my deep support of the Technology Utilization Program at NASA, and especially the Rural Applications Team component of that program.

Even though I no longer serve on your committee, I am still both deeply interested in, and proud of, the Technology Utilization Program at NASA. I truly believe it is one of our government's success stories.

It seems that NASA, more so than any other federal agency, has the capacity to continue to develop a multitude of new technologies. Our space program has led to so many wonders. Whether we reflect on how we could live without teflon, or speculate on how our lives might be affected from future Space Station discoveries, I expect we will continue to marvel about how dramatically the space program can touch the lives of each and every one of us.

NASA led the way for all other federal agencies in the technology utilization field. The concept seems to be finally catching on at several other federal agencies, and I feel certain that the growing acceptance and support of the program on a government-wide basis is largely due to the success of the NASA program.

I feel there are three very important components of the technology utilization program. The first phase is "technology dissemination", which occurs when NASA distributes its written materials about new technologies.

The second phase is "technology transfer", which occurs when an industrial applications center provides information on a specific technology to a particular business or individual.

The third phase is "technology commercialization", which occurs when a technology is actually developed into a new product or process in the private sector. After that phase -- after a technology has been disseminated, transferred and commercialized -- technology utilization has taken place, and our world will be the better for it.

I know from personal experience how helpful NASA's Technology Utilization program has been in actually getting new technologies commercialized in the private sector. In Rural America, where I come from, that effort has been greatly assisted by NASA's Technology Utilization Rural Applications Team.

The Rural Applications Team concept is still very much needed, and I urge you to include it in a reauthorization of the Technology Utilization Program this year.

Thank you.

ER.NASA

Mr. NELSON. Well, you were right on in your comments. A most recent example of technology utilization is the thin film of plastic with grooves that was put on the underside of the Stars and Stripes sailboat that gave it an estimated three-quarters of a knot advantage in the race in bringing America's Cup back to America. Now, that was a NASA invention which was done, Mr. McCurdy, in the aeronautical research at Langley Research Center in researching fluid flow over hard surfaces. And in this case it had the application on the underside of a sailboat.

That watch, a year and a half ago, cost me $19.00. I don't even know what you could buy it today, probably less than that. I do everything with that watch. I wake up to it. I run each day with a stop watch. I punch that watch off at two minus zero on pad 39–A. That watch is a direct spinoff of America's space program.

Last December there was implanted at Johns Hopkins Hospital a little micro-miniaturized computer in a patient's body cavity called a PIMS, Programmable Implantable Medicine System. And this system, because of that computer, will dispense the drug each day, the prescribed dosage at the prescribed time without the patient having to take the daily injections of whatever that medicine is.

Those are just three examples of technology spinoffs and application and utilization from the space program that are rather dramatic examples, indeed, of what you're talking about.

So, I appreciate you underscoring to us the need for this.

Any of the members have any questions or comments?

Mr. WALKER. Just a comment, Mr. Chairman.

I do thank you for being here, Wes, and bringing the subject matter back to our attention, because I think the one thing that we sometimes fail to talk about is just how successful we've been in the NASA program in doing some of this, and how much more needs to be done.

The only thing I would say in terms of comment though is, you've got to have technology to transfer, too, which means that we have got to keep this agency on a leading edge. Because there is no way that we are going to be able to transfer technology if NASA is not out on the leading edge. We can't allow NASA budgets to become so operationally oriented that we lose that leading edge technology that is then capable of transferring.

And that really is going to involve a partnership between some of the things that this committee defines as priorities, and some of the things that are done at the powerful Appropriations Committee, and some of the things that are done within the budget process. Because the fact is that, as all of those things are now coming together, we stand the very, very real possibility of losing NASA as a leading edge agency.

And, you know, I appreciate the message you brought to us, and I hope that we are going to be able to put together the kind of partnership that saves the advance research that NASA is so good at doing, so that we have the technology to spinoff in the future.

Mr. WATKINS. If you will yield, Mr. Walker. Let me say this, you know, one of the things I've tried to do, you know, in working with the Federal Laboratory Consortium, and through the Stevus and Wilder Chapter 11 setting aside only one-half of one percent, I'd

like to see us maybe if we could raise that up to one percent of what we are spending in just research for technology transfer.

Bob, back when I was on the committee, when we first initiated that, and over the years, in the Federal Laboratories we've asked a technology transfer person be designated, to work with the technology in these billions of dollars, 50 billion plus dollars we spend on research, most of it shelved.

Now, if we can work with that research, like you say, we got to have the basic research, leaves us out on—but we got to then take that and get it implemented.

I'd like to ask the committee to follow up on that, if they would look into it, and have the staff maybe look into it, because I put $300,000 through the Commerce, in order to try to make sure we train the technology transfer agents out there. The technology transfer—well, first, let's look at it. A scientist, many of them want just to do research; they don't want to mess with this technology, you know, they want to do research.

Mr. Chairman, let me say this, if we could get the technology transfer agents, and when I put the money in there $300,000 through Commerce, to set up a standard type activity for the technology transfer people to report in, to cuff the Center for Utilization of Federal Technology; that will allow that technology to be disseminated or leased from the various laboratories and come in to a central location, so that in Duran, Oklahoma we can access that technology to make it usable for our people.

We haven't, I found after about five or six years, Bob, that a technology transfer maybe in Chicago doesn't even know what he's supposed to do; and another one out in maybe Oklahoma or out in California had a totally different concept of what they're supposed to do. We need to make sure they understand that this is a very, very significant role that we have in America today, and let's get our research, what's viable and practical out to the American people so that it could be utilized.

Mr. WALKER. But it's going to come to this subcommittee to do something, for instance, like Save the ACTS Program, the Advanced Communications Technology Satellite Program, it has been cut out of the NASA budget, it has been cut out of the President's budget. We're probably going to have to save it here because we think it is important.

We are going to have to be assured somewhere along the line that we have enough money in the budget, so that when we save that program we in fact can do it within a budget climate that allows it to go forward. We're going to have to have the Appropriations Committee acting on that, because that is exactly the kind of technology that then has the ability to be transferred in the private sector. It's not only the fact that you get the switching for communications, but that same switching technology is what permits us, for example, to do something that will be appropriate to the TAM Subcommittee that gives us the ability to put computers in cars that hook on to the satellite and take cars at 150 miles an hour down specially built roads hooked in to satellite technology. You know, all of that comes about as a result of putting those advance satellites into place. And that's what I'm concerned about is, even if we put the mechanisms out there that assure that the tech-

nology transfer takes place once we've developed it, it doesn't do a bit of good if we don't have the advanced technology to begin with.

Thank you.

Mr. WATKINS. One last comment I'd like to make, if I may.

Mr. Chairman, when I was down in your district at the Kennedy Space Center a number of years ago for one of the shops there, I—I think you might have been there—but I asked the General and number of dignitaries there came around to my questioning, around the table, that I would like to speak to their technology transfer agent. They all looked at me with a blank stare. I did that because I wanted them to hopefully understand that this person is important.

And I'd like to just ask this committee maybe to elevate that person, so that the people that are out there in these laboratories and all know that this is something that we're serious about. And that's getting from the research, that technology, out to the private sector so we can bring on new products, build new businesses and industry, and build jobs for America. But I think it's going to take that elevation by some of you showing that interest. I've done that on several occasions, when I've gone to federal labs and they've kind of looked at me, you know, questionable, and they realize, yes, we do have one, you know.

Thank you very much, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Watkins.

All right. Dr. Robins. And I'm going to ask Chairman McCurdy if he would chair, so that I can run to a meeting with Mr. Roe, and then, if time permits I'll be back. But thank you, Chairman McCurdy.

Mr. MCCURDY [presiding]. Dr. Robins, welcome. Your full statement will be admitted into the record without objection, and we look forward to hearing your statement this afternoon.

**STATEMENT OF DR. HOWARD ROBINS, DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ON BEHALF OF JUNE GIBBS BROWN, ASSOCIATE ADMINISTRATOR FOR MANAGEMENT, ACCOMPANIED BY RAYBURN A. METCALFE AND CHARLES TULIP**

Dr. ROBINS. Thank you. I'm glad to be here. I'm not here under the best of circumstances, in the sense that I'm filling in for Mrs. Brown, who is home recovering from surgery. She is doing well, and we expect her back next week.

I have a couple people here with me that I'd like to introduce: Mr. Metcalfe on my left from the Personnel Division, and a familiar face to many of you over here on my right, Charlie Tulip, from the Comptroller's Office.

And I am here to talk about what is not the most glamorous part of our budget, but one, as Mr. Nelson pointed out, that is extremely critical to us and to our mission, and I don't think I could state that quite strongly enough, the R&PM budget, which you will note in the testimony, 70 percent of which goes to paying the salaries and benefits of that very valuable resource, our people, who produce what we happen to think is probably one of the most im-

portant products there is, namely knowledge and technology, and we were just talking about that technology here.

I think Mrs. Brown's written statement talks a fair amount about the budget and the details and changes from last year and so forth, and what I would really like to rather concentrate on is just the subject that we've been emphasizing is so important, the issue of people, and I'd like to begin with the increase in the budget, the 625 FTEs, and FTEs, as you know, stands for full-time equivalents, and if you'll forgive me, from here on out, I won't use that terminology.

I've been in the agency for over 30 years, most of it in the R&D side, in flight projects, flight programs, and I've had the good fortune to know and work with a lot of very good people, but I never met an FTE, so I just won't use that term anymore.

That 625 increase is directed toward decreasing deficiencies identified by the Rogers Commission, specifically in terms of providing additional oversight of our contractors and the work going on in our Field Centers from Headquarters and to strengthen our in-house capabilities.

Now that has been tentatively allocated out, 330 to the Manned Space Centers for SR&QA, program management, engineering, operations and program support, literally across the board, strengthening every area. By the "Manned Centers," of course, I mean Johnson, Marshall, Kennedy, and the NSTL.

The second largest increment is to Headquarters. That's distributed to program and functional management areas, but a large chunk of that is again focused in areas that relate directly to the recommendations of the Rogers Commission—the safety, reliability and quality assurance, an increase of 33 person in NASA Headquarters. In the Office of Space Flight, Dick Truly's office, which manages the Shuttle, 25, and 103 to the Space Station Office, which, as you know, we're in the process of transitioning a major part of the Space Station program management up to Headquarters.

The final 25 in there is to the Inspector General's Office for audits and investigations, again a further strengthening of our oversight.

Now the question, of course, that we have is whether or not this is adequate. This is very definitely concentrated, as I said, in response to the Rogers Commission recommendations, directly ties to the Shuttle and the manned complex in the agency and so forth.

Following behind the Rogers study was a study done by General Sam Phillips. This was a comprehensive look at agency management in all three of its basic elements from stem to stern—general management, program project management, and institutional management—looking at the organization, looking at the people, looking at the processes and so forth. This study ran for about a half a year. He generated about 100 recommendations.

Now we've been studying those, and we've converted those into what we will call 66 actionable items. The lesser number is due to a combination of certain of the recommendations and the fact that some of the recommendations are things in the nature of policy guidance, things that we should adhere to in the future in doing planning and so forth.

Just this past week, Phil Culbertson's office issued those 66 actionable plans out to the other offices. They are to put together detailed plans. The Office of Management, is going to coordinate that activity, and we're going to track and report to the Administrator every month progress on implementing those recommendations.

When we get through doing that—and that will be going on over the next several months—in parallel with all of that, we are planning to put together our story of the implications of that for FY 1989. I anticipate that we may find some need for some additional requirements in the way of people.

Let's talk a little bit more specifically here about some of the problems that we have been experiencing. One of the first is the one Mr. Nelson alluded to; it is, in fact, the first, what I will call our weakening competitive position versus industry.

We are now at entry-level paying up to $8000 a year less than the private sector in certain engineering disciplines. We are now at the executive level paying from $32,000 up less than what people holding comparable positions in the private sector are paying. And those gaps seem to be growing.

Now as you look to the future, will this get better, or will it get worse? Well, we think it's going to get worse. The National Research Council has done a study of engineering education and looking to the supply of engineers in this country in the future, and that supply is going to go down. That's what demographics tells us.

So we're going to be competing from a disadvantage for an even scarcer resource in the future. We're very concerned about that.

The next thing—and I think Mr. Nelson alluded to this, too—is the potential for high retirement, and that's likely to grow with the new federal retirement system. We have, as you know, a bulge at the upper end in the older group. In the 50 to 54, we have a plot, and you may have seen this, a bar chart of the number of people in various five-year increments—50 to 54 is the greatest in the agency. Our overall age in the agency is about 44, I believe it is now.

If you take that chart apart and break it down into scientists and engineers, the story is even worse. There's even greater discrepancy there.

However, we have a couple things here. Fortunately not everyone retires when they're eligible, by any stretch. In fact, of the number of retirement eligibles in any one year, only about a fifth do. What tends to happen, though, is that every time there's a threat on the federal Civil Service retirement system, we'll see a spurt. Any major pending hit could cause us, I'm afraid, a considerable problem.

Looking to the future, now if there is no such hit and because everyone doesn't retire, we may well be able to get through. We have a very dedicated group of people who remain committed to the agency, in spite of the greater opportunities outside. If we can get by a few more years until we grow this young group that we've concentrated recruitment on in the past few years, get them up a little in experience and we're talking about next year, putting together a significant increase in our training and development, we just may be able to get through.

In the long-term, though, I think the agency, ten, twelve years or so down the road, is going to have a very serious problem with this new federal retirement system, because it is based on a portable pension, and the fact is that the current system, the so-called "golden handcuffs," has resulted and provided a lot of incentive for a lot of our people to stay in the system.

What are some of the solutions to this? Well, on the lower end of the problem, there are a number of things. First of all, we're very supportive of the Administration's legislation proposed by OPM based on the China Lake experiment. We've been following that very closely. China Lake has a lot of very similar problems to the kinds of things that NASA has encountered. We watched the benefits to them; that's an R&D outfit, as I said, very similar, and we expect that they would accrue to us.

That would address, though, only the entry-level pay and some of the other difficulties that we have with the personnel system. It really wasn't set up or geared to an R&D agency.

However, in parallel with that, we are also looking at other options. Just last week, we brought in one of our senior executives from one of our field centers. We're going to look at other options. We're going to do everything we can to be prepared to cope with, however this goes, and have some alternatives to present. We will certainly keep you informed of that, because we will probably be needing your support.

I want to conclude with one final note here that's kind of a little bit of good news and a little bit of bad news. It has to do with the last part of the testimony on equal opportunity. We have been doing very well in recent years. A very large percentage of our fresh-in S&Es have been the female and the minority. That's the good news. The bad news is that if you take that and break it down a little bit, you will find that it's very heavily female, that the minority supply out there is pretty sparse, and based on the results of the recent National Research Council study, that picture looks fairly grim in the future. But in the area of female, at any rate, we're doing pretty well, and I think our record is about as good as there is.

Thank you. I wanted to keep this brief, and I'll be glad to try to answer any questions you may have.

[The prepared statement of Mrs. Brown and answers to questions asked of Dr. Robins follow:]

STATEMENT
OF

JUNE GIBBS BROWN
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS COMMITTEE
ON SCIENCE, SPACE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

Messrs. Chairmen and members of the Subcommittees:

I am delighted to be with you today to discuss institutional matters. As some of you know, I returned to NASA in December as Associate Administrator for Management after a brief period in private industry. My earlier tour with NASA was as Inspector General from 1981 to 1985.

Let me first discuss the Research and Program Management (R&PM) appropriation which provides funds for the performance and management of research, technology and test activities at NASA installations, as well as for the planning, management and support of contractor research and development tasks necessary to meet the Nation's on-going objectives in aeronautics and space. The activities funded by the R&PM appropriation are to: 1) provide the civil service staff with the technical and management skills to conduct the full range of programs for which NASA is responsible, 2) provide base maintenance of facilities and manage their use in support of research and development programs; and 3) provide effective and efficient technical and administrative support for NASA programs. For 1988, an appropriation of $1,598,000,000 is requested.

This budget is not overhead, as some have characterized it, rather it is the heart of our programmatic capability and capacity. It provides funding for 22,425 full-time equivalent (FTE) permanent and temporary civil service people at eight major field installations and Headquarters. This civil service workforce is NASA's most important resource and is vital to future aeronautics and space research activities. About seventy percent of the R&PM Budget goes for salaries, benefits and other related costs of the workforce. Three percent is used for travel, critical to manage successfully the agency's in-house and contracted programs. The remaining amount provides for the research, test and operational facility support, and for related goods and services needed to operate efficiently and effectively the NASA installations and to accomplish approved missions.

1987 BUDGET CHANGES

Before addressing the Budget request for 1988, I want to discuss with you the changes from the 1987 Budget presented to you last year.

The 1987 R&PM request presented to you last year was for $1,441,000,000. Since the Budget was submitted, two major changes have occurred to affect the 1987 level. In August, as a result of the Challenger accident, we amended the 1987 request to $1,425,000,000, a reduction of $16,000,000. We

were able to achieve that reduction because the level of activities planned at the Johnson, Kennedy and Marshall centers for the 1987 Budget were based on plans before the accident. In summary the reductions came from civil service overtime ($1.0 million), utility consumption and rates ($8.1 million), and reductions in support contractor staffing levels and in other goods and services needed to support the centers ($10.4 million). These reductions were partially offset by an increase in travel due to the GSA imposed increase in travel per diem rates last summer.

The other major change in 1987 is the impact of the 1987 pay raises and the new Federal Employees Retirement System (FERS), which together will cost $41.5 million. The cost of pay raises in 1987 will be $24.9 million, $2.8 million for special rates for lower graded scientists and engineers that went into effect in October, 1986 and $22.1 million for the general pay raises that went into effect in January and February, 1987. The cost of FERS in 1987 is estimated to be $16.6 million. The large cost for FERS results mainly from the shift of the "real cost" of retirement for newer employees from the Treasury to the agencies and from the estimated cost of the agencies contribution to the thrift plan portion of FERS.

THE FY 1988 ESTIMATE

The 1988 Budget Estimate of one billion five hundred ninety eight million, an increase of $131.5 million over the current 1987 plan, provides for: a civil service ceiling of 22,425 workyears (FTE), an increase of 625 from the 1987 level; the full year cost of the 1987 pay raises; the added cost in 1988 for continuation of the implementation of FERS; a minimum level of travel to support Agency missions and programs; support service contractor effort at anticipated wage-rates; utility usage consistent with programmatic requirements at projected rates; and supplies, materials, equipment and other minor contracts and services at anticipated price levels consistent with the planned resumption of Space Shuttle flights.

I will briefly summarize the 1988 request for the R&PM appropriation by major functional category.

1. Personnel and Related Costs one billion one hundred eleven point six million: The 1988 estimate for Personnel and Related Costs is $88.6 million higher than the 1987 Current Estimate. The largest portion of that increase, $44.9 million is for the added cost in FY 1988 of implementing FERS. This increase results from having more new employees automatically covered in FERS and the expectation that a substantial number of our employees covered under the Civil Service Retirement System will switch to FERS in 1988. The full-year cost of 1987 pay raises will be $8.2 million and the cost of career development, changes in reimbursements received and other changes will be $6.6 million.

The balance of the increase in this function, $28.9 million is the salaries, benefits and related costs of the additional 625 FTE. This increase of 625 FTE represents the first increase in NASA's civil service ceiling in over ten years. The increase is the result of our assessment of what was needed to correct the management deficiencies identified by the Rogers Commission. The additional FTE will be assigned as follows:

A. 330 FTE will be assigned to the Office of Space Flight Centers (128 to Johnson, 27 to Kennedy, 160 to Marshall and 15 to NSTL). These FTE will be used to strengthen the centers' SR&QA, program management, engineering, operations and program support elements.

B. 25 FTE for the NASA Inspector General will strengthen audit and investigations programs.

C. 270 FTE to strengthen Headquarters program and functional management. The staff assigned to the new Office of Safety, Reliability, Maintainability and Quality Assurance will be more than doubled, increasing from 27 to 60 FTE. The offices of Space Flight and Space Station will increase by 25 and 103 respectively, including Systems Engineering and Integration or Level A'. The other program office (Space Science and Applications, Aeronautics and Space Technology and Space Operations) will increase 41 collectively. The remaining 68 FTE will be allocated to staff and functional offices.

We feel that this modest increase will provide adequate support in the obvious areas where repeated civil service cuts in the past have caused understaffing to occur. We are in the process of implementing the recommendations of the Phillips Committee. When those recommendations are fully understood and implemented, we may conclude that additional civil service staffing is needed in various parts of the Agency. I will later provide more details of the changes we have already made as a result of the Phillips Committee Report.

2. Travel ($43.3 million): Since over 85% of total NASA funds each year are spent for activity in the private sector away from NASA installations, travel for both programmatic and management purposes is integral to the effective and economical accomplishment of program objectives. In addition, because NASA's civil service workforce is so heavily technical, over 50% of our permanent people are degreed scientists and engineers, travel to scientific meetings, seminars and symposia is important for the interchange of information and maintenance of technical currency. In 1988, the largest part of the growth in travel funding is related to the 625 FTE increase in civil service staffing ($4.3 million) and the balance represents our estimate of the expected increase in transportation, per diem and miscellaneous travel expenses.

3. Operation of Installation ($443.1 million): The 1988 plan provides for anticipated changes in the price levels of support service contractor wage and utility rates, the alteration in the funding plans from reimbursable launch vehicle activities, the change in price levels of support provided as center requirements change and Space Shuttle flights resume. In addition, the increase in support required because of the additional 625 FTE is included. The amounts by subcategory are as follows:

A. Facility Services ($232.5 million): The 1988 estimate, an increase of $18.5 million over the current 1987 level, covers anticipated rate and price increases for utilities, support contractor effort, supplies, materials, equipment and minor contractual efforts, and minor changes to support levels. This increase will help provide support activities for the resumption of Space Shuttle flights as well as support to the additional civil service ceiling.

B. Technical Services ($90.0 million): The $6.6 million increase in 1988 covers anticipated support service contract wage rates, cost of supplies, materials, equipment and other contractual efforts, and support to the additional civil service personnel.

C. Management and Operations ($120.5 million): The $11.7 million increase in this subcategory results from the support for the increased

civil service staffing, increased costs of supplies, material, equipment and minor contractual effort, the anticipated changes in support service contractor wage rates, and the changes in levels of support required, driven chiefly by the resumption of Space Shuttle flights.

In summary, the 1988 budget requirement of $1,598.0 million is to provide for 22,425 full-time equivalent civil service workyears and to support the program and support activities at eight major NASA installations and Headquarters, consistent with the Research and Development, Space Flight, Control and Data Communications, and Construction of Facilities plans.

This concludes my statement on the Research and Program Management Budget.

I will now highlight some other institutional items that will be of interest to you.

The first is in an area in which you, Mr. Chairman, have been most supportive through your regular and special hearings and other activities. That is, of course, the continuing health and vitality of the NASA civil service workforce. While this is a legitimate concern of every Federal agency at this time, there are certain characteristics which make it particularly acute for NASA. Along with our mission which broadly and heavily impacts United States science, technology, national security, and economic activity, we have a workforce whose knowledge, skills, and talents are very much in demand in the private sector.

Since its inception, NASA has accomplished its mission through a unique team relationship with the private sector and educational institutions. However, this team effort requires an "expert" in-house workforce to assure the public that programs are economically and effectively managed and that there is high quality R&D leadership in all relevant areas of rapidly changing technology. Meeting this essential requirement of acquiring and retaining top quality personnel is increasingly difficult due to several factors or conditions which I'd like to discuss.

First, our Civil Service salary benefits, particularly at entry and executive levels, are increasingly noncompetitive with the private sector. For example, the maximum allowable special rates for engineers at entry levels are as much as $8,000 below private sector salaries for comparable positions. In many cases, this means we cannot successfully compete with NASA contractors who can offer the same challenge of working on the Nation's space program but at significantly higher salaries. At the executive levels, the recent pay increase of $3,000 for our most senior executives may help some, but it doesn't come close to eliminating the gap ($32,000 and up) at the Associate Administrator or comparable levels.

Secondly, we are in a time of projected market place shortages in critical engineering disciplines as decreasing enrollments in engineering schools are expected to persist into the 1990's. The National Science Foundation projected shortages of 23,500 aeronautical engineers and 128,000 computer specialists by this year. At the same time, Bureau of Labor Statistics figures show demands by 1995 to increase 41 percent for aeronautical engineers, 65 percent for electrical engineers and 85 percent for computer specialists. Our current salaries and benefits situation, coupled with possible skills shortages, creates apprehension about our future staffing ability.

A third area of concern is our aging workforce and the potential that exists

for mass retirements. By 1989, 17 percent of our scientists and engineers will be eligible for retirement. Additionally, although our turnover for reasons other than retirement has been quite low, we may see dramatic changes, particularly among experienced workers, as a result of the portability features of the new Federal Employees Retirement System. Without the "golden handcuff" of the current retirement system, NASA may become much more susceptible to having its very best employees leaving for higher pay and benefits in the private sector after 5 or more years with the agency.

The three matters I have just discussed would pose a real management challenge in any private sector organization. However, the situation becomes much more difficult when one must accomplish the agency's mission within the cumbersome, complicated constraints of the Federal personnel system. It has become widely recognized that the Government's personnel system is not working as well as we need it to work. Numerous legislative proposals have been set forth, including the Administration's proposal for a government-wide simplified personnel system, similar to the Navy demonstration project at China Lake and San Diego which experimented with a flexible pay system based on performance. We support this initiative being led by the Office of Personnel Management. First, it is responsive to many of our problems, and secondly, we believe that personnel changes which recognize and accommodate the diversity in culture, values, problems, workforce needs, and unique missions of the Government's components are critical to accomplishing NASA's mission. In addition, NASA is assessing additional needs not addressed by a simplified personnel system and identifying alternative solutions. We are bringing one of our field center executives in this month to coordinate an immediate effort in this direction. We hope to consult this Committee and enlist your support for future initiatives.

I would now like to follow up on a major step we announced we were taking last year and which has now yielded results.

As we reported last year, Dr. Fletcher asked Gen. Sam Phillips, former Apollo Program Director, to head a comprehensive study of NASA's management. Its objective was to conduct an independent assessment of NASA practices, the effectiveness of NASA's organization, and make recommendations to the Administrator outlining actions needed to improve agency practices and organization.

The general observations of the study were that NASA is fundamentally a sound institution, with many outstanding people who reflect continuing dedication to the success of NASA's programs. It was noted that many positive steps have been taken in recent months to strengthen the organization, management, and practices of NASA.

The Committee made over 100 recommendations in the areas of External Environment, Planning, Managing the Mission, Managing the Institution, Executive Management, and other subjects.

The Administrator has directed the initiation of the implementation of the approved recommendations. An action plan document has been required for each recommendation, and progress against the plans will be reported monthly and tracked to completion.

The following organizational elements have been established:

- Associate Administrator for Safety, Reliability, Maintainability and Quality Assurance. George Rodney holds this position.

- Associate Administrator for Policy and Planning. Phil Culbertson has moved into this position.

- Associate Administrator for Space Operations. Bob Aller is assuming this responsibility.

- Program Director in Washington for Space Shuttle, Arnold Aldrich, and Space Station, Tom Moser.

- Associate Administrator for External Relations. Hollister Cantus has joined NASA in this position.

- Associate Deputy Administrator - Policy. Willis Shapley has returned to NASA in this position.

- Associate Administrator for Communications. This is vacant.

- Associate Deputy Administrator - Institution. This is vacant.

Recruiting is in progress to fill the vacant positions and complete the new team.

EQUAL OPPORTUNITY

NASA continues to make progress in increasing the representation of minorities and non-minority women in its workforce. Minorities now comprise 13.5% of the full-time permanent workforce, up from 13.1% at the end of FY 1985. Women comprise 25.8% of the workforce, up from 25.0% a year ago. In specific areas: of scientists and engineers--9.7% are women, including minority women, (8.7& last year) and 9.7% are minorities including female minorities (9.2% last year), of Senior Executive Members, 4.5% are women (3.7% last year), and 4.5% are minorities (3.9% last year); and 10 (38.5%) of the NASA civilian Astronaut Corps are minorities or non-minority females. Other related information is presented below:

HIRES:

- Of 619 scientists and engineers: 244 (39.4%) were minorities and non-minority women.

- Of 296 hires and conversions from nonprofessional positions in professional administrative occupations: 198 (66.9%) were minorities and non-minority women.

- Of 549 other hires: 395 (71.9%) were minorities and non-minority women.

PROMOTIONS:

- Of 1,855 scientists and engineers: 573 (30.9%) were minorities and non-minority women.

- Of 741 in professional administrative positions: 507 (68.4%) were minorities and non-minority women.

- Of 1,538 other promotions: 939 (61.1%) were minorities and non-minority women.

In addition, 21 handicapped persons with targeted disabilities were hired, exceeding NASA's goal by 7. As of the end of FY 86, NASA employed 183 persons with targeted disabilities (188 last year).

In closing, the activities supported by the R&PM appropriation are critical for maintaining the core capability of the NASA centers, which has been instrumental in the success of the aeronautics and space R&D programs. R&PM funding provides the vehicle that assures the quality of our people and our facilities and represents an investment in the future of our country.

I would be pleased to answer any questions you may have.

Responses to written questions submitted by Chairman Nelson, resulting from the March 19, 1987, hearing at which Mr. Robins testified.

QUESTION 1:

NASA is currently in the process of selecting a new group of astronauts.

a. What is the current size of the astronaut office? How big should it be?

b. How many astronauts does NASA plan to select this year?

c. What is the current criteria for Pilot selection?

d. What is the current criteria for Mission Specialist selection?

e. Has that criteria changed over the last nine years?

ANSWER 1:

a. There are currently 83 astronauts assigned to the Johnson Space Center. However, a number of these are on permanent or temporary assignments to other positions and, consequently, are not available for flight assignment or to perform other Astronaut Office functions. The number of astronauts currently available for flight assignment and other functions is 76.

b. The number of additional astronaut candidates to be selected in 1987 has not been finally determined. That number will be based on an evaluation of the following:

1. A prediction of the retention of the astronauts currently in the corps,

2. The predicted flight schdedule including types of missions to be flown, and

3. The number of astronauts required to perform the other permanent and temporary assignments levied upon the Astronaut Office.

At this time, we anticipate that the number will not exceed fifteen.

c. and d. The qualification requirements for the Astronaut Candidate Program are as follows:

1. Pilot Astronaut Candidate

o Bachelor's degree from an accredited institution in engineering, biological science, physical science, or mathematics. An advanced degree is desirable.

o At least 1,000 hours pilot-in-command time in jet aircraft. Flight test experience is highly desirable.

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- o Ability to pass a NASA Class I space physical.

- o United States Citizenship.

2. Mission Specialist Astronaut Candidate

- o Bachelor's degree from an accredited institution in engineering, biological science, physical science, or mathematics. Degree must be followed by at least three years of related, progressively responsible, professional experience. An advanced degree is desirable and may be substituted for part or all of the experience requirement (master's degree = 1 year, doctoral degree = 3 years). Quality of academic preparation is important.

- o Ability to pass a NASA Class II space physical

- o United States Citizenship

In addition to the basic requirements, the evaluation of applicants for the Astronaut Candidate Program is based upon the breadth, quality, and applicability of the applicants backgrounds (both academics and experience) and demonstrated performance.

Communicative ability, adaptability, ability to function as a member of a team, and motivation to join the space program are also factors for those applicants interviewed.

e. The criteria have not changed significantly since the 1978 selection process.

QUESTION 2:

How much of the $41,484,000 for FERS and the pay raise can NASA absorb in FY 1987? What will be the consequences of this?

ANSWER 2:

The action of the House Appropriations Subcommittee on HUD-Independent Agencies on the proposed funding of the FY 1987 cost of the pay raise and FERS is as follows:

a. Supplemental appropriations of $13.0 million (one-half of the pay raise costs as provided for in the continuing resolution);

b. A total of $6 million to be absorbed from within the R&PM appropriation;

c. $7 million transferred from R&D; and

d. $15,484 million transferred from SFCDC.

The absorption of the $6 million in R&PM will come from any savings from a combination of (1) actual FERS costs less than estimated and (2) deferral of purchases of supplies, materials, equipment or services into next year. The transfer from SFCDC will come from the Tracking area by deferring purchases in that

program. The funds for transfer from R&D will come from various programs (the specific decisions are currently under study) by deferring program activity into FY 1988.

QUESTION 3:

If NASA were given only enough in the R&PM budget for FY 1988 to hire half of the 625 FTE what would be the impact?

ANSWER 3:

The additional 625 FTE are requested for FY 1988 primarily to correct the management deficiencies identified by the Rogers Commission. If NASA could add only 300-325 FTE in FY 1988, priority would be given to correcting those deficiencies most closely related to safe return of the Space Shuttle to flight. Beyond that, additional FTE would be applied to correcting the more pressing deficiencies remaining. The major programmatic impact would be to the build-up of civil service attention to the Space Station program, as the people planned to go to that program would be held on the Space Shuttle because only half of the planned increase would have been provided.

QUESTION 4:

What, if any, changes in personnel have occurred since the Challenger accident? Do you feel these changes are a result of the accident?

ANSWER 4:

Assuming that "changes in personnel" means morale and/or attitude toward NASA as a place to work, we have no empirical data base which allows comparison of morale pre and post Challenger accident. However, informal input from our Management Education Program (MEP) sessions and various other management colloquia suggests continuing pride in being part of the NASA work force and strong commitment and dedication to maintaining technical excellence. Additionally, our acceptance rate for recent science and engineering graduates was 70 percent in FY 1986 - compared to 59 percent in FY 1985. To the extent that grade point average reflects the quality of these new hires, we experienced almost no change (3.26 in 1985 and 3.27 in 1986). In summary, we do not have evidence of "changes in personnel" resulting from the Challenger accident.

Mr. McCURDY. Dr. Robins, your plight is not totally unique in the Federal Government. I wear a few other hats. One is on the Armed Services Committee and the other is the Intelligence Committee, and I can assure you, at least in the intelligence arena, they are faced with many, many similar problems, not only in the area of attracting and recruiting qualified candidates. They have a tremendous problem in the area of recruiting minorities within the service, and I think that the Federal Government as a whole certainly has to look at this, and it's not an easy one to solve.

Let me run through a series of questions. I, too, am going to try to be brief, and we will probably submit a number of written questions for a more detailed response, but there are a few that I think we need on the record.

The first is, not included in the amended FY '87 budget is $41,484,000 for the added costs of the Federal Employees Retirement System and for the January 1987 general pay raise.

According to NASA, the President's budget request contains language allowing NASA to transfer funds from R&D and space flight control and data communications to fund this increase.

When will NASA submit a reprogramming request?

Dr. ROBINS. Charlie, I'm going to let you handle that one.

Mr. TULIP. The agency is in the process of identifying which of the R&D and space flight and data communications programs will be affected. Based on some information that we received from our Appropriations Subcommittee, it appears that we will receive a supplemental appropriation of $13 million. They are asking us to find another $6 million of it in the R&PM, and then we will transfer the balance from R&D or SFCDC.

My understanding is that the letter will be prepared sometime later this month or early in April and be communicated to the Congress, identifying the specific programs that will be affected.

Mr. McCURDY. So what you're telling me is, some $22 million will come from R&D and flight control?

Mr. TULIP. I think that's the arithmetic, yes.

Mr. McCURDY. You said $13 million supplemental, $6 million from the others.

Mr. TULIP. Yes, that's right.

Mr. McCURDY. Roughly $22 million. You have not identified those specific programs as of yet?

Mr. TULIP. Not fully within the agency, and until the Administrator approves the list, I don't believe it's possible to comment.

Mr. McCURDY. Right. Okay. We'd like to see that list as soon as possible, as far as the details.

As indicated, you are going to hire 625 new employees, and you've broken those down. Of the 330 new hires assigned to the Office of Space Flight at the various centers, how many will be working in the safety and quality control area, and why are they not assigned to the Office of SRM&QA as field reps instead of the Office of Space Flight?

Dr. ROBINS. Do we have the breakout?

Mr. TULIP. Well, I think the answer to the latter part of the question is that the NASA history has been that the people at each of the centers report to the Center Director, rather than being representatives from Headquarters. That's been our historical organi-

zational pattern that line authority runs down through the Center Director.

Dr. ROBINS. Now clearly the not making them part of the program project offices, that would put them under the direct supervision of the Program Project Managers, and you wouldn't really have the—what would you want to say—the independent check verification that you'd want to have. I don't know that the centers have yet made those allocations.

Mr. TULIP. It appears that of the 330, about 66 of them will be devoted toward increasing the SRM&QA function. They will be basically half at Marshall and half at Kennedy. The Johnson increases will be within rearranging their existing workforce.

I think one other point that would be helpful to you, within each center there is an independent SRM&QA function that reports to the Center Director. The liaison between that and Mr. Rodney is very detailed.

Dr. ROBINS. Right.

Mr. TULIP. It's just been our practice not to have the people at a center reporting to anyone other than the Center Director from an organizational standpoint.

Mr. MCCURDY. What will the 103 new hires in the Office of Space Station be doing?

Dr. ROBINS. They will be taking over what was the Level B function down at JSC, prior to shifting the Program Director systems engineering integration activity up to Headquarters.

Mr. MCCURDY. What is Level B again?

Dr. ROBINS. Okay. I'm sorry. The Space Station organizationally is structured—I guess it really goes down about five levels. The top level, Level A, is Andy Stofan's office. That is the traditional headquarters program management organization.

Level B is the systems engineering and integration organization. That was located down at the Johnson Space Center.

One of the recommendations of the initial phase of General Phillips' study was that we move to Washington that office and strengthen the program direction activity and systems engineering activity. And those 103 are to expand Andy's office to accommodate that. Andy will have under him directly there in Washington both what is his Level A, and Level B we're now calling Level A-prime, until we get a better name for it.

Mr. MCCURDY. 625 puts you at your personnel ceiling, 22,425.

Dr. ROBINS. 22,425, right.

Mr. MCCURDY. How do you plan to accommodate the need for additional personnel in future years with that margin? Are you going to increase the margin, or are you going to go for a ceiling increase? How are you going to do it?

You're up to the ceiling now, max. What kind of flexibility do you have in future years?

Dr. ROBINS. In future years?

Mr. MCCURDY. Yes.

Dr. ROBINS. Well, as I indicated, we are in the process of implementing the Phillips study in all of its aspects, if you will, and to see if that's going to impose a requirement for additional personnel.

Clearly, the Shuttle accident changed the long-term staffing plan in the agency, the Shuttle would have been slowly destaffing as the Space Station was building up. That obviously is not going to happen, and this 625 certainly reflects that.

But beyond that 625, we just established that, I guess, six, eight weeks ago, so the details of even working out those allocations within the centers, I expect, are still going on.

Mr. McCURDY. What is the status of NASA's recruitment program? You were talking about it earlier, and I was curious as to—for instance, if you're bringing in quality control people, what levels of experience do you think you're able to attract, or are you taking people directly out of engineering schools, or are you taking folks out of industry, or is there—what level of professional are you getting?

Dr. ROBINS. Hopefully a significant portion of that has got to be experienced people. I would expect, three things: attempting to hire some experienced people from industry, attempting to convert some of our own senior people who might be able to make that kind of conversion, and then thirdly bringing new fresh-out people into it.

One of the things that we've doing recently is, we've worked with the Army. They have an SR&QA school. I believe it's down in Texas, a one-year program, that takes young engineers recently out of school. We're going to have our first class. We're going to put five in this coming year, and we will probably grow that up to, you know, some stable level to meet our needs in the future.

Mr. McCURDY. Are these—the quality control people, are you talking about—what mix of sciences are you talking about or engineering skills are you talking about? Aeronautical engineers? Are you talking about industrial engineers; are you talking about mechanical? I mean, what——

Dr. ROBINS. I'm going to guess that the bulk of them would be mechanical and electrical.

Not so much aerospace engineers, such as what I am, typically tend to get into overall design of vehicles, trajectory analysis, mission planning, those kinds of things. Mechanical and electrical generally tend to be deeper into the subsystem development, that kind of thing.

Mr. McCURDY. The gentleman from Louisiana?

Mr. HAYES. Thank you. I was listening to the testimony earlier regarding the impact under the Federal Employees Retirement System, and it seems to me that in light of the other statements that you are making regarding competing with private industry, I want to be clear if my impression would be that that would be favorable to you, not harmful to you. Not in a budget sense, but in a sense of trying to close some of the gap in competition by improving the retirement system.

Dr. ROBINS. I would think on the front end, it will be. I have looked at it because—well, obviously there are a lot of civil servants who have been around looking at it because as you know, we have an open season coming up and we all have to decide whether to remain in the Civil Service Retirement System or convert over.

None of us has had a chance to do the detailed analysis yet; we don't even have the forms; I guess they are just now coming in. But

be that as it may, what we are told is the long-term civil servants are better off staying in the current system and that the newer ones may be better off in the new system. And that would tell me that that is a better system for younger people starting out. It certainly appears that way to me and I have that decision to make at home because my wife works for NASA. So I am looking at it. Yes, I think it will help on the recruiting; it is a more attractive system.

Mr. HAYES. In converting the cost difference for—let's say among just recruitment rather than senior management group for the time being, just at the recruitment level, do you think there is a quality loss because of the inability to compete with private industry?

Dr. ROBINS. We haven't really done a study of that. About a year ago, I looked at a computer listing of all 300 or 400 people that we had hired. I was a little surprised to see the distribution of where they came from. I think there has been some movement down from the top schools, but I haven't done a study to actually do that. That's just an observation I made reviewing the list.

Mr. HAYES. Would it be your recommendation that there ought to be? In other words, if we look at the quality of the station or the Shuttle, shouldn't we also—and I don't mean this in a demeaning fashion or suggesting that any NASA employee is not very competent, but I mean shouldn't we be doing a quality level study in preparation as well? If we are interested in equipment shouldn't we be interested equally in people?

Dr. ROBINS. Absolutely. Absolutely. Among the moves and things that we are doing in response to the Challenger accident and to the Phillips Study is we are going to have a very significant effort to upgrade what we call our human resources effort activity in the agency. And certainly that will be a part of it.

Let me come back to one thing you said, talking about the new retirement system helping out. Yeah, I think it will help but I don't think I should overstate that. The 22-year olds typically, when they are looking at benefits, aren't asking that much, frankly, you know, about the retirement system. And in fact, as I said, by the time they really start to think about it, toward 40 or so, that's where I think we have got our problem.

Mr. HAYES. When they start thinking about it—if they start thinking about it toward 40 or so, then that must mean that an extremely large percentage of your present employees are close to retirement age.

Dr. ROBINS. It's close to 20 percent. That's right.

Mr. HAYES. To replace that—I will refer to it, for lack of a better term without the alphabet as—upper level management, will that come from grooming in-house, or will a substantial portion of that have to compete with private industry for senior, equal experience people? In other words, will it come through promotion or will it come through outside sources, or will it be a mix, and if a mix how would you guess the percentage of that mix would fall?

Dr. ROBINS. I think it depends on what happens. I think if there are no really further serious threats on the retirement system—and I am talking about the type of thing that happened this past year with the change in the tax aspects—that we just may be able to get by. But if there is something very significant that comes up,

we are likely to see people seriously bailing out. And I don't think anything we could do in the way of training and development, et cetera could we cope with that.

As I said, if you look at the agency overall, you can see that dip in the 30 to 40 age range. If you look at the curve for S&E's, scientists and engineers, that's 50 percent of our activity and obviously, the element that executes the main mission of the agency, that curve is even more pronounced. It was tremendous hiring beginning in 1958 and running through about 1962 or 63, and those people are sneaking up on that 55.

But as I said, a lot of people do stay on long past when they are eligible to retire. And if that happens, then this younger group can move up and will have time to grow and develop.

Now talking about hiring from the outside, I talked about our problem at the lower end and the problem at the higher end. We haven't looked at the middle in some time. The last time we looked we were relatively competitive in the middle ranges. In other words, where industry might hire someone in a significantly higher salary, we have been able to promote people faster than they have and, you know, shrink that gap over the first five to ten years or so.

Mr. HAYES. I guess the point that I am making with all the questions is that it appears to me that we should know the answer in budget preparation for future years. As long as it takes a budget to move around here, we're going to have to know the answer to that quality question long before you come with a budget request.

That's really all I had.

Mr. MCCURDY. The gentlelady from Maryland.

Mrs. MORELLA. Thank you, Mr. Chairman; nice to have you chairing the committee meeting.

Dr. Robins, it is a delight to have you here.

Dr. ROBINS. Thank you. Nice to see you personally after talking to you.

Mrs. MORELLA. Thank you. I wanted to pick up on a couple of issues; one that has to do with your recruitment and retention that was just mentioned, and mention was made by you in your testimony about the China Lake experiment. Now you also said it is not currently for R&D, but could it be adapted——

Dr. ROBINS. No, no. It is for R&D. China Lake is an R&D lab.

Mrs. MORELLA. Are you saying that it is not, then, adapted to NASA right now?

Dr. ROBINS. It was a demonstration project conducted by OPM under a very special——

Mr. METCALFE. As part of the Civil Service Reform Act.

Mrs. MORELLA. So what I am getting at is in your statement it was like we might be interested in doing something like that, but it would have to be adapted for us, for you. Is that correct?

Dr. ROBINS. I think that the adaptations for us would probably be relatively small because of the similarities in mission and circumstances and so forth. As I said, we followed that for sometime.

One of the requirements of this law that allowed the demonstration project to take place was that no two demonstration projects could be basically identical or very similar, correct me if I am wrong, Ray—we had not been able to design a demonstration

project for ourselves that was significantly different from China Lake because they were addressing so many of the same issues. So we followed that with considerable interest.

Mrs. MORELLA. So you would be willing to be involved in something like that in terms of the pay and incentives and all of that.

Dr. ROBINS. That's right, we would.

Mrs. MORELLA. Secondly, I wanted to ask you about the Mars Observer, because this has been going back and forth in my brief tenure in the 100th Congress. I mean, is it going to be 92, is it going to be 90. Are you not asking for funding to make it 90, and therefore, it would be 92?

Dr. ROBINS. That would be in our R&D budget, and I am just not really ready to address that one. That is part of the Space Science and Application of Planetary Program, and the funding for that would be in the R&D budget, and the Office of Management is not involved in that per se.

Mrs. MORELLA. Maybe somebody on the staff could check it.

Mr. TULIP. There are several options under discussion. I don't believe that there has been a decision at the Administrator's level to select one or the other to accelerate the Mars Observer. I know it is being worked on but I really can't tell you what the status of it is other than it is being worked on.

Mrs. MORELLA. The public would love it. It really would do a great deal I think to enhance everything that NASA is doing in terms of that patriotic spirit, in fact, that we can do it.

I also wanted to ask you—I know that NASA is planning to bring people from Houston and from Huntsville to the greater Washington area, and I applaud that, I think it is fabulous. You know, it's awfully expensive, as many members of Congress can tell you, to live in this area. Is there going to be any look at maybe geographical supplement? Are you going to be able to hold your good people in this area?

Dr. ROBINS. Well, I think it's going to be a bit of a problem regardless of where the site ultimately is located up here.

Mr. MCCURDY. They could move it to Oklahoma. [Laughter.]

Dr. ROBINS. That's right.

Mrs. MORELLA. Now you've got the two sites ready——

Dr. ROBINS. What I have to do here is just give you kind of anecdotal information, if you will. We have several families down there at Johnson, and of course that is probably the worst place to be coming from at this particular time. You are familiar with the Houston economy. And they are assuming a lateral transfer with no promotion, coming to Washington. They are consistently calculating 20 to 25 percent cost impacts on themselves; the higher cost of living.

Mr. MCCURDY. If the gentlelady would yield for a second, are you going to buy their homes for them?

Dr. ROBINS. We have a program in essence to do that, but we find that that program is limited as to how effective it can be.

Mr. MCCURDY. NASA could end up with a lot of real estate loans hanging around. The FDIC is the largest landholder in both Texas and Oklahoma right now. [Laughter.]

Dr. ROBINS. We are using, I think, it's the Department of Transportation for any contract, and we are experiencing, let's just say,

only moderately good results with that. We are taking a look at that and seeing if we would do better with our own contract. But so far, we are not seeing a lot of promise in that regard. It is a difficult problem, the absence of locality base pay.

The only comparable cost of living area in the NASA complex is the Ames Research Center in California, and I suspect you have had Bill Ballhaus, the Director of Ames. If you get him going on the subject you had better be prepared to listen about his difficulties in recruiting right in the middle of the Silicon Valley and retaining them.

Mrs. MORELLA. No doubt this would be an ideal location, but nevertheless it is something I know that you are going to have to be looking into in terms of retention. Do you have an affirmative action office? That's another subject.

Dr. ROBINS. Yes.

Mrs. MORELLA. You do. I always look at percentage of women in high positions, and I notice that—what have you got, 4 percent, 4.8 percent, 4.6 percent. And when you consider they are 53 percent of the population, that is not much progress. You talked about the lack of minority progress, and I would say that it demonstrates that, too. But also, don't forget, too, that in terms of women you are dealing with a higher percentage also.

Dr. ROBINS. That's right.

Mrs. MORELLA. And I guess you do—I don't mean to put words in your mouth—I hope you do very vigorous recruiting because more and more women are involved—but not me; I'm of an older generation—but more and more women are involved in mathematics and science and engineering and all of the related fields.

Dr. ROBINS. You are right, and I happen to know a little bit about this because I am Chairman of the Headquarters EO Council, and also on the agency EO Council. I talked about this at the end of my comments here. The enrollment by women in science and engineering has been climbing rapidly in recent years. In some schools, including my old one, it's up to 25 percent. And from talking to the dean there, he says they are actually out-performing the men slightly.

At the same time, the minority, as I said, is very flat and very low percentage. But now let's talk about the women in higher positions, because—and that really comes home to roost with us here in Headquarters because in fact, Headquarters is the higher positions, if you will, in general.

What we are up against there is the demographics of years ago. The journeyman level at Headquarters in the S&E arena is, of course, a GS–15; typically 40 years on up. If you go back and look at enrollment in science and engineering by women and minorities, both, back in the times where they would now be able to hold senior positions, you find that enrollment was miniscule; very, very small.

In Headquarters, we just finished this past year updating a ten-year old study of equal opportunity in Headquarters. We found that in every category from ten years ago, and by any measure you wanted to come up with, the number of women had doubled and tripled. And that sounds good as a percentage, but you know, percentages are a little bit fooling when the numbers themselves are

relatively small. And the numbers are small but they are growing. We are definitely progressing.

We are having a lot more success in the professional administrative arena. But in the science and engineering, even though we have an increase there it has been very small because the supply stayed small for many years. And this business of women enrolling, in any significant numbers, in science and engineering is a relatively new thing.

Mrs. MORELLA. I would like to encourage you to continue that way. I always think it helps to send your team out to colleges and even high schools to talk about career opportunities in that field because I think that is kind of where you've got to get them, particularly in high school, maybe even junior high school.

Dr. ROBINS. Well, we have looked into that, too, as a matter of fact, and talking to the educators. I happen to be on the Selection Committee for the new Director of the Educational Division there at Headquarters, so I was there when we interviewed the various candidates for that position, and they came from many different areas of the educational community. And they all had said the same thing; you have to capture them in grammar school for science and engineering careers.

Mrs. MORELLA. That would be ideal. And finally, just give me a yes or no. Have you decided on the site yet?

Dr. ROBINS. No.

I have to be careful about compromising the selection process, but I can tell you there are no finalists in Oklahoma. [Laughter.]

Mr. MCCURDY. Well, that's your loss, not ours.

The—I have to concur with the recommendations and suggestions in the recruitment of minorities and also of women. Being the spouse of a physician, and the brother-in-law of an industrial engineer with a number of years of experience—I know where you can find an industrial engineer, by the way, with——

[Laughter.]

Some experience in the aerospace industry in quality control that is looking. So if you want, talk to me later.

Dr. ROBINS. I sure do. I have a phone call to return to Joyce Rodman when I get back this afternoon.

Mr. MCCURDY. I actually do.

After the Apollo fire some 20 years ago, NASA lost a significant number of senior people almost immediately after they returned to flight. Will you see the same problems after the next flight with the shuttle? Are you expecting problems?

Dr. ROBINS. You are asking me to speculate, but I would expect that when you have a situation like we do, with a large number of people eligible to retire and people staying past their retirement age, and knowing how people think. I was one of them for 30 years, you tend to make those career type decisions around major milestones like that. If you're working on a project, like that's my last one up there, Viking, that was when I came to Headquarters, after that one, the landing and so forth. It is likely, you know, to trigger somewhat of a rush. But I don't know.

Mr. MCCURDY. Are your headquarters personnel—the average age is 44, you said, for NASA across the board. What would the average be in the headquarters?

Dr. ROBINS. I think we've got that in our book here, if you'll bear with us a second.

Mr. MCCURDY. I assume it would be older?

Dr. ROBINS. Older, yes, definitely.

Mr. MCCURDY. Considerably. So there's a question of continuity of management if you reach this milestone, and there's going to be a drop.

Dr. ROBINS. I'm surprised. 44.3.

Mr. MCCURDY. I'm surprised, too.

Dr. ROBINS. In fact, you can almost see that from up here. It's pretty consistent across the agency. This is just the various NASA installations. But you don't find a very young spot in it.

Mr. MCCURDY. Well, I guess you'd have to break it down within headquarters as far as occupation.

Dr. ROBINS. Exactly. That's exactly right. The thing that is driving that down is primarily clerk-typists, secretaries, that sort of thing.

Mr. MCCURDY. Gentlemen, very good. We appreciate our testimony today. As I indicated earlier, I am sure there will be some written questions to follow up, and we'd appreciate your responses to those.

Dr. ROBINS. We'll be more than happy to. Thank you.

Mr. MCCURDY. Thank you, sir.

Our next witness will be General McGarvey, and I think we will also bring up Mr. Frankle at the same time, and even though they're not going to testify on the exact same things, I think we could go ahead and hear from both first, and then cover the questions from there. Since we are down to the bare bones of the joint subcommittees here.

General McGarvey, you may proceed.

**STATEMENTS OF GEN. BILLIE J. McGARVEY, DIRECTOR, FACILITIES ENGINEERING DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY TED ANKRUM; AND EDWARD A. FRANKLE, DEPUTY COUNSEL, OFFICE OF GENERAL COUNSEL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC**

General MCGARVEY. All right, sir, Mr. Chairman. Again, I appreciate the opportunity to present the '88 budget request for construction of facilities, and before I start, I would like to introduce Mr. Ted Ankrum on my left, who is the new Deputy Director for Facilities Engineering. He came to us just recently from the Nuclear Regulatory Commission.

Mr. MCCURDY. Why don't you just write your name for the Clerk there so he can have it for the record.

General MCGARVEY. I do have a detailed statement which I'd like to submit for the record.

Mr. MCCURDY. It will be admitted into the record.

General MCGARVEY. With your permission, I'd like to summarize that statement for you.

Mr. MCCURDY. We'd appreciate that.

General MCGARVEY. In five or six minutes.

Our request does total some $195.5 million. It's a modest but a balanced request against the priority requirements of the agency for construction of facilities.

We have allocated it in major categories—and when I say balanced, I allude to these categories. There's about $90.6 million for discrete or major projects, and there is $65 million in the request for the minor projects, those under $750,000 and under 500,000 each.

For our planning and design activities, we have a request for $16 million to support the other activities. And we have a new initiative that I will address a little later for environmental compliance and restoration this year for $23.9 million. Before we address each of these major activities in the program, I would like to just briefly bring you up to date on some of the major activities and recent accomplishments since we were here last year in the facilities world.

In the Space Shuttle arena, we completed a new cargo hazardous servicing facility at the Kennedy Space Center for handling hazardous cargo payloads, about a $14.5 million facility.

We constructed and put into activation a new solid rocket motor assembly and refurbishment facility for SRM components.

We also completed the extension of the runway at Easter Island in the South Pacific as an abort landing site for launches out of the West Coast.

On the Space Science and Applications side of the house, we completed a new central engineering building at the Jet Propulsion Lab, and we also completed an addition to the Network Control Center at the Goddard Space Flight Center in conjunction with and shared costs with the Department of Defense.

We activated a new 34 meter antenna in Spain to assist in the encounter with Neptune for the Voyager II in 1989.

On the Aeronautical side of the house, we have had three new facilities that came on line during the past year. The Icing Research Tunnel at Lewis was upgraded to the tune of $3.6 million. A new Fluid Mechanics Laboratory was constructed and activated at the Ames Research Center for a little over $4 million. And then the large facility in the aeronautical world is the Numerical Aeronautical Simulation Facility for $19.5 million. That was just recently activated last month with a formal dedication at Ames.

With that brief summary of prior year activities, I would like to address for you the major requirements and requests that are contained in this budget. To begin with, in support of the Space Station development, we have four projects that total $25.8 million. The biggest one of those is an addition to the Mission Control Center at Johnson to provide a Space Station support center for controlling and supporting both the construction of the Space Station in space from the launch of the first element through the completion of it, when it reaches a fully man-rated capability, and is on continuous orbit.

In the same light, we have an addition to the Simulator Training Facility, a smaller project, for $3.4 million at Johnson, that's required to conduct the integrated training and simulation with the crews that will man the Space Station as well as the ground controllers that will provide the continuous support around the clock for the Station.

We also have a modification of a Process Technology Facility at the Marshall Space Flight Center which is required to develop the fabrication techniques for fabricating the common module for the Space Station, and for developing the on-orbit repair techniques and enhancing the productivity of the Space Station for maintenance and repair while it's on orbit.

In addition, the fourth item is a small project for $3.6 million at Kennedy to provide the site preparation and the supporting utilities for a Space Station Processing Facility and check-out facility prior to launching the elements that make up the Space Station, the resupply activities, the payloads that go up to the Station for experiments, attached payloads, and the free-flying platforms.

When you move to the next major category, it would be those that support the Office of Space Flight. We have only one project this year for the Space Shuttle, and that's an LC-39, Operation Support Building at the Kennedy Space Center in the amount of $17 million. This is our first major effort to move from the temporary facilities, the modular relocatable trailers that we have at Kennedy, and provide some of the key engineering and quality control people with an adequate permanent office facility at Kennedy. This building will house about 1550 people, of some 1950 in the immediate vicinity of the Vehicle Assembly Building that require office space.

In the Space Science and Applications arena we have two projects. Both of them are located at Goddard. The first one, and the largest one, is the second and final phase of a two-phase project to provide a new Spacecraft Systems Development and Integration Facility.

This is at $8.6 million. Last year we received $8 million for the first phase of the project.

The second one at Goddard is a utility reliability modification project to modify the electrical power stand-by capability and the chiller or cooling capacity to react to short time interferences and loss of power at Goddard at $2.9 million.

In the Aeronautics and Space Technology program, we have four projects, for $29.9 million total. The largest of these is a second—again a second and final increment of a two-year phased project for an Integrated Test Facility at the Dryden Flight Research Facility. This project was in the program last year at $17.5 million for the entire facility. A $15 million reduction was made in the facility program in appropriations last year. In order to absorb that reducation, we had to phase this project in two years in order to accommodate $10 million of the $15 million reduction.

A second project in aeronautics is a Hypersonic Propulsion Facility at the Langley Research Center in support of hypersonic propulsion technology development. It adds a new vacuum system to a couple of hypersonic test cells at Langley, and provides an increased capability, both in mach number and in altitude for that particular facility.

We have, an addition to the Research Analysis Center at Lewis, at Cleveland, for $9.8 million. The research analysis center is the term given to the data automation center at Lewis, where all of the mainframe computers are located that support all of the research

and engineering activities, as well as the business administration computers.

The fourth aeronautics project is also at Lewis, and that is a major modification of their Engineering Research Building Complex for fan and compressor research. We're talking about large aircraft fan engines and compressors for propulsion systems. This does two things:

It provides a new control system for the electrical frequency converter and electrical power system and it introduces or interjects a chilled air capability to a number of test cells and locations within the engine research building. This permits them to perform tests at lower speeds and less stress on fans and compressors and increases their productivity. The last one I should mention to you is $6.5 million for those modifications to the engineering research building—for the fan compressor research; I'm sorry.

For Space Tracking and Data Systems, we have one project which is a new communications development antenna at Goldstone, California, by the Tracking and Data people, which is required to move to the higher frequencies in deep space communications. The communication folks call this KA band at the much higher frequencies. The lower frequencies now are so crowded that it's difficult to communicate and control spacecraft in deep space operations without moving to the higher capabilities and using wave guides as well as the higher frequencies.

This replaces an old 26 meter development antenna used for the same purpose at Goldstone. This cannot be modified to do this type of work.

In the minor facility category, we are requesting $65 million this year, compared to $61 million in the program last year, and we sincerely appreciate the strong support that these two committees have given to our minor programs in the past. These projects truly constitute the backbone of our institutional capabilities to keep facilities responsive and reliable, and at the same time permit us to modify those facilities to accommodate new requirements and new technologies. Without this minor project capability, we would really be in deep trouble.

The committee has seen fit to support these very strongly in the past, and we would certainly solicit the same type of support again this year.

We have in the categories that make up the minor facility program; $25 million for repair projects; $32 million for rehabilitation and modifications; and $8 million for minor construction. These collectively represent about 140 projects under $750,000 or $500,000 each, depending on which category they fall in.

The final category, and the one I'd like to take a little time with is the new initiative that we are requesting in this year's program. This is the $23.9 million that I mentioned to you earlier for environmental compliance and restoration activities within the agency.

We, like all other federal agencies, and like the private sector, are being inundated with increasing requirements and advancing deadlines for compliance on the environmental side of the house. And certainly our first concern is to protect the environment, and we certainly don't want to be parties to environmental pollution. Those are the things that we're trying to deal with.

We are asking this year for a separate funding source in the COF program. We are trying to identify a separate source that will not compete, or be placed in competition with the other major construction requirements in the agency, so that it can be limited strictly to those environmental compliance requirements.

We need a separate fund source, to avoid trading them off against other construction requirements. We need the flexibility within that funding source so that we can do a number of different activities as opposed to straightforward construction projects. We need to do studies and site investigations. We have to do remedial assessments after having identified a particular situation that requires restoration or correction. You need to do these remedial assessments to determine what has to be done, and to try to scope the size of the effort.

Our most critical problems are hazardous waste removal and disposals, and we have to deal with those. We have deadlines that are being rolled forward for mandatory compliance—when I say mandatory, by statutory compliance.

We need the flexibility to do clean-up activities, to clean up contaminated sites and close those sites in order to meet the environmental requirements. They do not always manifest themselves into construction projects. They often manifest themselves into ongoing operational activities, and that's why we need flexibility in the fund source. We need to replace PCB transformers, for example, which our deadlines have been rolled forward now to early 1990 for the majority of transformers containing PCBs.

We have asbestos abatement problems to contend with, and most of those you cannot or it's extremely difficult to projectize them and say this is what we're going to do for a given amount of dollars. They become level of efforts in order to do those things, in many cases. There are some that manifest themselves into remedial construction projects, and we have about three of them that we've put in this category in this request, such as the replacement of underground tanks with aboveground tanks to meet the requirements for getting rid of leaking underground tanks.

We have also proposed that the fund source can only be used for environmental restoration compliance, that it not be able to transfer for some other activity.

Whatever reasonable reporting requirements that the Congress would want to attach to it, we would certainly be amenable to doing that. We would like to see it at some workable project or activity level, somewhere let's say between $2 and $3 million per activity. If we had to exceed that, we would have to come back and report to the Congress what it is we are going to do and why we have to exceed, if it is a $3 million level.

[The prepared statement plus answers to questions asked of General McGarvey follow:]

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
MARCH 19, 1987

**STATEMENT**
**OF**

**BILLIE J. MCGARVEY**
**DIRECTOR OF FACILITIES ENGINEERING**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**before the**

**SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND**
**SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS**
**COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY**

**HOUSE OF REPRESENTATIVES**

Messrs. Chairmen and members of the Subcommittees:
I appreciate this opportunity to present the NASA Construction of Facilities budget request for FY 1988. Our budget request is for $195.5 million. This is a modest but balanced budget request for construction activities that are vital to providing reliable and responsive facility support for carrying out the mainstream research, development, testing and operational responsibilities of NASA.

The FY 1987 request has been tailored to meet our continuing objectives of preserving and enhancing the capabilities and effectiveness of our unique aerospace research, development, test, and operations facilities and our supporting institutional facilities and systems. $90.6 million is allocated to discrete or major facility projects, $65 million to minor projects, $16 million for planning and design, and $23.9 million to environmental compliance and restoration activities.

Prior to addressing the FY 1988 requirements, I would like to briefly update the subcommittee on some of the major construction activities that have been completed since last year.

Several key facilities for the Space Transportation System at Kennedy Space Center were completed in this period. These include the Cargo Hazardous Servicing Facility, which provides an increase in hazardous payload processing capabilities; the new Solid Rocket Booster Assembly and Refurbishment Facility to improve production flows for the assembly and refurbishment of

SRB components. Also, a 1,400-foot extension of the runway at Easter Island was completed to provide a South Pacific abort landing capability for Shuttle launches from Vandenberg AFB.

A new Central Engineering Building at the Jet Propulsion Laboratory was completed and placed in service in October 1986. A new 34-meter Deep Space Network antenna was also completed at Madrid, Spain on schedule and will be used for supporting the Voyager 2-Neptune encounter, reducing communications overload at this site, and minimizing science data losses.

A jointly funded NASA/DOD addition to the Goddard Space Flight Center Network Control Center was completed to provide additional control interfaces between the Tracking and Data Relay Satellite System and its users.

A number of major projects in support of aeronautical research needs were also completed. These include the rehabilitation of the Icing Research Tunnel at Lewis Research Center to ensure the continued capability and reliability of this unique facility; construction of a new Fluid Mechanics Laboratory at Ames Research Center for basic research and cooperative efforts with the academic community; and completion of the Numerical Aerodynamic Simulation Facility at Ames to assure continued leadership in computational fluid dynamics research and application.

## SPACE STATION FACILITIES

Our Budget request includes four discrete projects required for Space Station development and testing activities. One of these projects is an addition to the Mission Control Center at the Johnson Space Center at an estimated cost of $15.8 million. The project provides a four-story addition to the existing Mission Control Center to meet requirements for continuous on-orbit operations support to the Space Station. The existing Mission Control Center will continue to be fully utilized in support of Space Transportation System missions. The facility needs to be constructed in this year's budget to support operations procedures simulation and verification well in advance of the first element launch.

The second project is the construction of an addition to the Simulator/Training Facility at Johnson for $3.4 million. It is needed now to house the additional simulators/trainers required for fully integrated training of flight crews and ground controllers to support Space Station operations.

The third project is a $3.0 million modification of the Process Technology Facility at Marshall Space Flight Center. This project converts some existing areas and adds 2,500 square feet to provide for the development of new techniques for Space Station common module fabrication and on-orbit repair. These activities require the development of special equipment, tools, materials, and techniques which have to be tested in a simulated space environment to verify the effectiveness of each.

The fourth Space Station project is $3.6 million for site development and utility tie-ins for a Space Station Proecssing Facility at Kennedy Space Center. This project is the first increment of a planned 3-year project to provide prelaunch and post-landing processing of non-hazardous Space Station elements, periodic resupply missions, and on-orbit maintenance packages. Prelaunch processing must begin approximately a year prior to the first element launch and construction of this facility must begin in 1988 to provide the necessary site preparations and supporting utilities for the processing facility.

## SPACE FLIGHT FACILITIES

The construction of a Launch Complex 39 Operations Support Building at the Kennedy Space Center for $17.0 million is needed to provide adequate office facilities for Shuttle support personnel currently housed in temporary relocatable office structures in the Vehicle Assembly Building (VAB) area. This building will provide permanent space for approximately 1,550 of 1,950 civil service and contractor personnel who were displaced from the VAB due to safety hazards associated with Solid Rocket Booster stacking and integration operations. The nature of their work requires that these people be housed in the immediate vicinity of the Shuttle assembly area. The morale and efficiency of key people needed to achieve the projected Shuttle flight rates will be improved and operation and maintenance costs are expected to be reduced by approximately $800,000 in the first year of operation. Additional savings will accrue by avoiding replacement costs of the short-life trailers.

## SPACE SCIENCE AND APPLICATIONS

The second and final increment of funding to complete the Spacecraft Systems Development and Integration Facility at the Goddard Space Flight Center is included in our request at $8.6 million. The FY 1987 increment provides the site preparation, supporting utilities and the basic building structure. This FY 1988 increment

will complete the construction and provide a complete and usable facility for testing, integration and checkout of large payloads, satellite servicing, and interface verification of Space Station platforms and attached payloads.

A second discrete project at Goddard for $2.9 million will provide increased utility reliability for the electrical power and chilled water systems supporting communications and control of the Tracking and Data Relay Satellite System, Shuttle flights, major space science satellites, and DOD missions. This project will provide short-term backup power and cooling to allow placing electronic and computer equipment and spacecraft into a safe mode in the event of short term electric power failures.

## AERONAUTICS AND SPACE TECHNOLOGY

Four discrete projects are included for Aeronautics and Space Technology research and testing activities. A second and final increment of the Integrated Test Facility at the Dryden Flight Research Facility is included at $10.5 million. The total project was initially included in the FY 1987 CoF Program at $17 million. Due to the $15.0 million reduction in appropriations in the FY 1987 CoF Program, it was necessary to reduce the FY 1987 funding by $10 million and request a second increment to complete the facility in FY 1988. The $500,000 increase in the total project cost is required to accommodate inefficiencies associated with the phased funding and a modest inflation for slightly longer times for procurement of equipment items and a slightly longer construction period.

The first increment funded in FY 1987 will provide the site preparation, supporting utilities, foundations, and structural steel frame. This second FY 1988 increment will complete the facility and provides the exterior cladding, mechanical and electrical systems, and equipment and interior finish. The completed ITF will provide the much needed capability to perform integrated testing, validation, and check-out of highly interdependent aircraft systems.

The second project modifies the Hypersonic Propulsion Facility at Langley Research Center by adding a new vacuum system at an estimated cost of $3.1 million. The modified facility will enable supersonic combustion ramjet (Scramjet) combustor and inlet-combustor component testing at the higher altitudes and mach numbers for advanced aircraft development such as the National Aerospace Plane.

The third project constructs a $9.8 million addition to the Research Analysis Center at Lewis Research Center. This project will provide an additional 46,000 square feet of space to accommodate new computers and equipment, required support services and personnel needed to meet increased computational requirements. Theoretical, scientific, and engineering changes in research methodology, including increased reliance on computer modeling in lieu of physical testing, have resulted in significantly increased computational support requirements.

The fourth aeronautics project is also at Lewis and requests $6.5 million for modifications in the Engine Research Complex for fan/compressor research. This project replaces the control system and instrumentation for the variable frequency power system and provides a new refrigerated air system that will enable testing of new generation fans and compressors for advanced propulsion systems.

## SPACE TRACKING AND DATA SYSTEMS

A project for $6.4 million at Goldstone, California will construct a new 34-meter, high-efficiency Deep Space Network Antenna to replace an existing obsolete 26-meter development antenna. The new antenna will be used in the development of high efficiency transmitting and receiving capabilities at higher frequencies and improved antenna pointing. These developments are needed to increase spacecraft tracking data rates, navigation precision, and enhance radio science measurements.

## MINOR FACILITY PROJECTS

Your continued full support of our minor programs request is greatly appreciated. The Repair, Rehabilitation and Modification, and Minor Construction projects that comprise the minor programs continue to provide the backbone for NASA's facility support activities and institutional capability. These projects, with strong support by you, enable us to address many of our most pressing and widespread smaller facility problems. With facilities the age of ours, extensive repairs are needed every year to continue to protect the investment in these unique and valuable aerospace R&D facilities. Your support of our rehabilitation and modification of existing facilities has been a key factor in modifying our laboratories and test facilities to undertake new tasks and exploit new technology developments. These projects help preserve and enhance the capabilities and utilization of our

facilities and help ensure their continued safe and economical use. In a like manner, the minor construction projects permit us to build very limited but essential additions or critically needed new small facilities.

## ENVIRONMENTAL COMPLIANCE AND RESTORATION

A new initiative is being requested this year for a separate funding source for environmental compliance and restoration requirements. Our request for $23.9 million will provide the necessary studies, assessments, design, and remedial projects for environmental compliance and restoration measures at NASA field installations and Government-owned industrial plants. The purpose of this program is to protect the environment and enable compliance with mandatory statutory requirements and standards.

A separate fund source is being requested due to the need for a broader flexibility in the use of funds for this purpose, than the regular or customary facilities construction projects. The program includes such measures as studies or assessments to determine current status of possibly contaminated sites and options for remedial action, environmental restoration, hazardous waste removal and disposal, clean-up and closure activities, and removal of unsafe buildings and debris. NASA, as is every other Federal agency and private entity, is faced with statutory deadlines for compliance with new or recently amended laws regarding hazardous wastes. The normal progression for environmental projects is an assessment of the nature and extent of potential environmental pollutants; a study to determine the most feasible and economic remedial action; design actions if required; and finally execution of the remedial action. The remedial action may frequently take the form of a construction type project. Deferral of such projects or activities, after having been identified, until the next budget request cycle would not be consistent with the National interests in aeronautical and space activities. Failure to comply with the mandatory standards and requirements incur the risk of closedown of vital operations by Federal, State, or local environmental officials.

A separate fund category reserved solely for environmental compliance and restoration purposes with the flexibility to undertake studies, assessments, design, and remedial projects without imposing separate project or activity limitations is needed to protect the environment and enable orderly and timely compliance by NASA. In order to preserve the

Congress's control to the maximum extent practicable, we also propose that the resources authorized and appropriated for this program may not be applied to any other activity.

## CLOSING

In closing, we sincerely appreciate your continued support of the NASA CoF budget request and the vital facility requirements that it provides for all NASA programs and mainline operations and activities. This completes my prepared statement, and I will be pleased to address any questions you may have.

Responses to written questions submitted by Chrm. Nelson during the March 19, 1987, hearing at which Gen. McGarvey testified.

QUESTION NX-1a:

What is the basis for the total cost ($64 million) estimate for the Construction of Space Station Processing Facility?

ANSWER NX-1a:

A preliminary engineering report (PER) has been completed for the FY 1988 increment and extensive in-house engineering estimates by KSC based on program requirements are the basis for the FY 1989 and 1990 increments for the total facility.

QUESTION NX-1b:

Has NASA explored private sector opportunities for building the Space Station Processing Facility? Has NASA done any cost comparisons between private sector and government funded facilities? If so, over what term where they based and what were the results?

ANSWER NX-1b:

Yes. We explored satisfying this requirement by determining if the capability existed or was being planned in the local private sector for processing large, space station-size elements and payloads. Although integration capability exists for relatively small payloads, i.e., in the single pallet or attached experiment size, no capability exists to process full orbiter cargo bay payloads such as the Space Station elements. Surface transportation constraints (bridge loadings, clearances, and grades) in the environs of the KSC further complicate off-site processing. Since private sector opportunities did not appear feasible for the reasons stated, cost comparisons of government funded vs. private sector were not undertaken.

QUESTION NX-2:

Assuming the new LC-39 Operations Support Building is built on schedule, as proposed in the budget, how many people will be accommodated by this new facility and how many will still be in temporary quarters?

ANSWER NX-2:

This facility will accommodate 1550 personnel, leaving about 400 personnel in temporary quarters in the VAB area. There are other requirements for permanent office space at KSC in addition to the VAB problem.

QUESTION NX-3:

Would the progress of Environmental Compliance and Restoration be expedited by establishing a separate program to carry out this work with more flexibility provided so that NASA management can react more quickly to contracting needs? Please elaborate.

ANSWER NX-3:

Yes. A separate program with the necessary flexibility for undertaking studies, remedial assessments, environmental restoration, hazardous waste removal and disposal, clean-up and closure activities, remedial projects, etc., is required to meet the myriad of Federal and State regulatory requirements. This would significantly improve our capability for responding in a more timely and comprehensive fashion to changing priorities and scopes that are inherent in the program. A separate fund source reserved solely for these purposes would also provide the Congress with clear visibility and accountability for how the funds are expended to meet environmental mandatory requirements.

QUESTION NX-4a:

What is the status of NASA's generic wind tunnel assessment and has the assessment progressed sufficiently to enable some early decisions to be made so that the upgrade work can commence early?

ANSWER NX-4a:

Dr. Raymond Colladay, NASA Associate Administrator, Office of Aeronautics and Space Technology, has initiated a major national assessment of future wind tunnel utilization requirements, and the state and adequacy of existing NASA wind tunnels to meet these requirements. This study effort will not be complete until late 1987. The assessment has not progressed far enough at the present time to make decisions as to what upgrade work should be started.

QUESTION NX-4b:

How critical are the requirements for an early "upgrade" and what can be done to expedite this work?

ANSWER NX-4b:

Until the assessment referenced above is completed, it would be premature to determine the urgency or priority of these "upgrade" requirements.

QUESTION NX-4c:

Two examples of the need for upgrade appear to be the 10x10-foot tunnel at Lewis and the 12-foot pressure tunnel at Ames. Please comment on these two facilities and how they might relate to this generic tunnel assessment.

ANSWER NX-4c:

Both the 12-foot pressure tunnel at Ames and the 10x10-foot at Lewis are examples of NASA's inventory that require "upgrade."

The 12-foot pressure tunnel was originally designed to operate at six atmospheres operating pressure. It has been progressively down-rated to one atmosphere due to cracks in the tunnel shell and cannot provide the test conditions necessary to satisfy industry, DOD, and

NASA requirements. The tunnel is classified as critical since it has such a high demand for use. It is important because of its low speed high Reynolds number capability with high quality flow and large model size.

The 10x10-foot tunnel at Lewis is used for a wide variety of propulsion testing. No major upgrade of this facility has been accomplished since it was initially placed into operation in 1955. Testing indicates that the seven drive motors have the potential for failure, and changes are required to improve productivity.

Both projects are potential candidates for the FY 1989 budget requests at this time.

Mr. McCURDY. General, let me interrupt you there. I know you are not aware of this but I chair a special panel in the Armed Services Committee on environmental restoration for all military facilities and was the conferee to the Superfund bill with Commerce on the Federal facilities issue.

I wrote the language that tried to create a compromise on that very contentious issue. I think in all honesty we were successful in protecting the Federal Government as much as possible from liability but at the same time, we certainly fall under the auspices of the Superfund and from a requirements standpoint, not from enjoying any of the benefits of the Fund, but certainly the requirements that come out of the environmental standards.

Do you have any MPL sites? Do you have any on the list?

General McGARVEY. I didn't understand you.

Mr. McCURDY. Do you have any MPL sites?

General McGARVEY.[1]

Mr. McCURDY. I think it would be important that you provide that to the Committee, a list of those, what would be your most significant and what is the source of contamination.

General McGARVEY. Well, for example, we are under compliance orders and have had to close a number of surface impoundments at the White Sands' Test Facility in New Mexico. We are under noncompliance orders from EPA and from the State of New Mexico, from their Environmental Division. We are having to use tanks, above ground tanks and then our contractors remove those to a designated site now and we are grappling with how do we clean up and close those surface impoundments.

Last year, we had to reprogram $5.6 million in order to build a new waste water treatment facility at the external tank plant at Michoud when the State of Louisiana banned deep well injections of hazardous wastes that we had been using in the past.

We have a number of these throughout the Agency, reported under OMB Circular 106 and these others. We have 30 sites that we are trying to come to grips with now, how to clean those up. We have tried to tailor our approach, Mr. Chairman, along the lines of the DOD environmental restoration fund.

Mr. McCURDY. I wrote that language in the DOD bill on the establishment of a separate fund and felt that it was necessary that we have an unified fund that DOD contributed to that was traceable and identifiable and could account for the expenditures from that. I think we started out with some $325 million the first year and it is growing significantly every year.

I would just suggest, since you have already mentioned that, Mr. Shaffer over at the Pentagon is the Director there and he can certainly work with you on that. I would be willing to help, also some of the members of the Armed Services staff, to work on this on a day to day basis. If you have problems or if you need some assistance there, we would be glad to facilitate that if we can.

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[1] FACTUAL ERROR.—Currently NASA does not have any sites included on the National Priorities List. A September 1984 GAO Report (GAO/RCED 84-188), "Status of Civilian Federal Agencies' Efforts to Address Hazardous Waste Problems On Their Lands," listed 26 potential CERCLA sites at 7 NASA installations. None of these have been included on the National Priorities List. We have begun the process of assessing these sites to determine the degree and extent of potential contamination.

You do need some flexibility and I understand that. At the same time, you are under some pressures and those pressures will only increase.

General MCGARVEY. That's correct.

Mr. MCCURDY. We tried to insulate Federal agencies from lawsuits but I'm not sure that agreement on the Superfund is going to hold up that long, so I think we need to proceed and you need to get those schedules on the move.

I am going to let the gentlelady of Maryland ask the questions on the space station construction. I want to take just a minute, unless she is under time constraints.

Mrs. MORELLA. No.

Mr. MCCURDY. Okay. If that is the case, then I would like to ask you about the first A in NASA, and that is the aeronautics, that my Subcommittee has to deal with. The gentleman from Florida, Mr. Lewis, the ranking member, we are in total agreement I think on the need for some major upgrades and maintenance of the wind tunnels.

When I went through the list with Ray Colladay, we found that many of the wind tunnels were older than the repairmen and that there hadn't been anything done to those in a number of years and that it was time to start making some investments. I was rather shocked that it had gone so long, that we let them get to the point that a lot of the deterioration is occurring at the same time and we are going to have a tremendous bow way occur, of construction costs and the last thing we need is for some of these tunnels to start going on the blink at the same time and we are going to have to shut them down in order to do some necessary construction.

I understand there is a study that is going to be underway to analyze those or assess the necessary work. I am going to ask you a pretty hypothetical question. It may not be as hypothetical as it sounds but I am going to put it in the record as hypothetical.

If NASA were directed or had appropriated an additional $10 million this year for assessment and work including acoustics work at the one tunnel, how would you structure that? How would you suggest those additional monies be structured? Would it be better to actually designate which areas needed to be looked at or would it be actual construction monies? Are you at a point where you have design stage monies? Would you have to go out and enter into a bunch of contracts overnight? Is there certain facilities that you could commence construction or rehabilitation work on?

General MCGARVEY. Well, sir, let me——

Mr. MCCURDY. It's only $10 million, General. If you go out of the question, then we may have to reanalyze that hypothetical. I know I'm putting you on the spot here.

General MCGARVEY. There isn't any question. We need to increase the size of the construction budget. Aeronautical facilities are certainly an element that need to be increased along with the rest. If the Committee were to say they wanted to add $10 million to aeronautical facilities and test facilities, the requirement and the determination as to which one, or if there is more than one, which should it be applied to, is certainly a decision that first has to be made by the AA for Aeronautics and Technology, who as you

well know, is Dr. Colladay. Dr. Colladay, after he has assessed the requirements, has to decide what his priorities are.

The 4 x 7 meter tunnel at Langley was a candidate project for 1989, submitted by the Langley folks, but in trying to accommodate the maximum number of priority requirements in the aeronautical facilities, the Program Office did not support it as a requirement in 1989. We simply couldn't fit it within the constrained budget and it did not come forward as a candidate. Whether Dr. Colladay would want to revisit that and say, yes, I agree that is the highest priority; he would have to answer that. I really can't answer it. He sets the priorities and it is my job to try to implement those for him.

Mr. MCCURDY. A little bit about your process then. Tell me about—I sit on the MILCOM Committee on Armed Services. Of course, the Department of Defense has specific guidelines of how construction is to be undergone and design requirements and you have to have 35 percent design before it moves forward to the Congress on construction.

What checks and balances, what oversight do you have on your construction dollars and design dollars?

General MCGARVEY. Well, once the priorities have been set and considering the budget constraints and what can be anticipated as budget run out figures, and what we think we are going to get for the next year, we try to size the overall construction budget within those guidelines.

Based on those priorities, in about the January timeframe, which was rolled forward this year to early December, we release the preliminary engineering funds in order that those projects——

Mr. MCCURDY. Is that done on a competitive basis? Those are all competitive bids?

General MCGARVEY. Those are done under architect engineer selection procedures, based on qualified people, qualified AE firms, and rigid selection procedures that follow the same Armed Forces procedures.

Mr. MCCURDY. Basically follow the same procedures.

General MCGARVEY. Same procedures except we do not have the congressional requirement that we have to be 35 percent complete in design when we bring it forward. Now, when we complete a preliminary engineering report, it in effect in many cases is about a 30 percent basic design, you have pinned down the conceptual requirement for it and a budget estimate that you are willing to go forward with to Congress and say this is what we believe we can build it for, and that's the basic purpose: To scope the project and the budget cost that we are going to request.

At that point then, the President's budget is submitted to the Congress, once we have cleared the OMB hurdle, and at that point in time, we release the final designs to try to keep the design breakages down so that we don't waste a lot of money on projects that aren't going to survive in the budget request.

Mr. MCCURDY. Okay. The gentlelady from Maryland.

Mrs. MORELLA. Thank you.

It is a pleasure to see you, General McGarvey.

General MCGARVEY. Thank you.

Mrs. MORELLA. Since I was told I should ask something about space stations, I was going to go into the environmental thing, but

I have an expert here who is the Chairman on it, although I hope you can cut through red tape on doing that. You may want to set up a special division for your environmental impact stuff and also have some accountability back to Congress so that can work out.

I notice you have among the projects, the fourth space station project, where you have $3.6 million for site development and utility tie-ins at Kennedy Space Center. I understand that in the three year project, it ultimately will cost a total of about $64 million.

General McGARVEY. That's correct.

Mrs. MORELLA. That's a lot of money; isn't it?

General McGARVEY. That is the current estimate. This would be the first phase or initial phase, simply to provide site preparation and all the supporting utilities to about a 27 acre site that would then accommodate the facility which would be built in two phases in 1989 and in 1990.

At this point in time, the estimated cost for the first phase in 1989 is estimated to be approximately $44 million and the third phase to complete it, about $16 million, and the total with the site prep is about $63 million.

Mrs. MORELLA. I think it is important when you start off with that first $3.6 million, that you realize what you are in for.

General McGARVEY. Oh, yes.

Mrs. MORELLA. I mean the ultimate cost.

I'm curious about where the money is going, why is it so expensive?

General McGARVEY. Well, we are talking about a very sizeable facility, roughly about 265,000 square foot of facility with a lot of clean room capabilities for processing the Space Station elements and the payloads that will be transported up to the Station itself.

For example, it would have the capability—in the basic concept now, for 8 simultaneous processing stations, and they would be in different stages, depending on the launch capabilities and on the need dates. You would have 8 stations where you could process full Space Shuttle cargo bay payload which is some 60 feet long and 15 feet in diameter. You have to have work stations, processing stations, where you can accommodate that size of a payload with work stands around it and in some instances about three of these in totally environmentally clean rooms.

Mrs. MORELLA. When you present your budget to us, how many reviews does it go through first, besides the congressional review?

General McGARVEY. I'd hate to say. At the centers, there is a Facilities Review Board, at all of the centers, normally chaired by the Deputy Center Director or the Center Director himself. They review their budget request for facilities for the upcoming budget year. Those requests in turn are submitted to the Program Office or the Assistant Administrator for Programs. In this case, Admiral Truly in the Office of Space Flight. Admiral Truly then has a review process in which his Deputy Center Directors sit on a Review Board with about three of his key people here in the Headquarters. They review all of their centers, and he has four centers reporting to him with their requirements. They prioritize those requirements and scrub out the ones they believe can be deferred and then they send those over to my office. My job is attempting to

integrate all of the Program Office's requirements into a proposed agency-wide budget request.

We have two senior management reviews, which either the Administrator or the Deputy Administrator chairs, with the AA's for the Program Office and the Comptroller and ourselves in the Facilities Office. We do that normally in the early May timeframe and in the mid-July timeframe in preparing the budget for submittal to OMB.

It has gone through a very strenuous scrub down and review process and distillation process, in a constrained budget. For example, this year in the budget development, requests from the centers totalled almost $470 million worth of projects. We went to OMB with a request of $208.6 million, and after the OMB reviews and our appeals, we are here with a $195.5 request.

So we almost screen out or distill almost two-thirds of the initial budget requirements and facilities requirements that the centers come forward with. It is a very orderly and very stringent process.

Mrs. MORELLA. OMB goes out to look at the site, too? They sent people out to look at the site?

General MCGARVEY. The Program Offices do and my field representatives are frequently visiting sites, three, four times per year as a minimum.

Mrs. MORELLA. I also wanted to ask you about the housing you are going to be adding at Kennedy, because I understand—somebody told me from the staff like 1,950 people are in temporary housing facilities, so you are going to build some housing there, but I don't know that it is going to accommodate 1,950 people.

So, I wondered, do you need money from our homeless bill that was passed? I'm just kidding, no I'm serious.

General MCGARVEY. We have a great number of people in temporary facilities. These are modular relocatable buildings, trailers and in some cases, railroad boxcars or converted boxcars, refrigerated boxcars, that serve the purpose very well because they withstand over pressures for locations out near the launch pads themselves. But we have even had to use many of these back in other areas because of a shortage of space.

This was generated primarily from a standpoint of safety reasons. We had to remove more than 1,800 people from the Vehicle Assembly Building at Kennedy, which is a large building where the orbiter is integrated with the solid rocket boosters and the external tank, for safety reasons. When we had to relocate these people in a very short timeframe, we had no alternative except to provide temporary facilities.

We have been living in those temporary facilities now since about 1982 and 1983, when they first started being activated. We do have in the launch complex 39 area, we have 611 of these relocatable facilities that house almost 2,300 people or 2,280 in the immediate vicinity of the Vehicle Assembly Building. We are trying to solve this problem for key people, and when I say key people, I'm talking about the engineers and the quality control people that oversee the integration process of the launch vehicles.

We have 453 units housing that 1,950. The new building will satisfy 1,550 of that requirement. The cost is the $17 million figure that we have.

Mrs. MORELLA. I look forward to visiting the Kennedy Space Center, which I will be doing in about a week. I have not been there.

I know that you probably keep those people working overtime, but I must say, when I first looked at it, I thought we were talking about where they slept literally.

General MCGARVEY. Oh, no. We are talking about only the folks that require office space.

Mrs. MORELLA. I realized it as you started talking. I thought that was terribly unfair. Thank you very much.

One final question though which has to do with the $64 million project, the space station processing facility at Kennedy. Have you looked into the possibility of the private sector helping out in some way in terms of the construction?

General MCGARVEY. The answer is yes. The KSC people, have looked at what is available and what interest there is in the immediate area. When I say the immediate area, of the Kennedy Space Center. And there is a small processing facility, a commercial facility there now that is in existence, but it will only handle very small payloads. It will not, in any form or fashion, start to accommodate these requirements—when we are talking about full cargo bay payloads, when you are trying to launch the individual elements of the structure and payloads for the Space Station. It could help offload some of the other processing of payload requirements at KSC, but it cannot satisfy this requirement.

We have the added problem that if it is offsite, not on the Kennedy installation, we have over-the-road difficulties with those large payloads with bridges and constraints on the highways and public access to KSC. So the preferred site is to put it on Kennedy. And then an obvious question is what precludes you from having the private sector build it on Kennedy, and our experience in trying to do that hasn't been very successful.

We had a couple of proposals here in the past such as the solid rocket booster assembly building that I mentioned in my opening remarks. We had initially proposed to have the private sector build that facility and we would amortize the cost through the production contract. The same thing held true for about a $20 million logistics support facility at KSC. We were not successful in doing that. The Congress directed us to put it in our appropriations request and have the government fund it.

So our folks at Kennedy and in the program office feel pretty strongly that we wouldn't get much further in current efforts in trying to encourage the priva e sector to make this kind of investment for this particular facility.

Mrs. MORELLA. Thank you. I am pleased that you did explore it. Thank you, Mr. Chairman.

Mr. MCCURDY. I thank the gentlelady. General McGarvey, thank you. We do have a few written questions that we will submit and we will try to keep them limited, though, as much as possible. I would also like to invite you to contact me at some point to discuss both the environmental and a couple other issues, and we can do that at some other point.

General MCGARVEY. I would be very pleased to.

Mr. MCCURDY. Thank you.

We will now proceed with Mr. Frankle, and I am going to turn the Chair over temporarily to the gentleman from Iowa, Mr. Nagle. Mr. Frankle is Deputy Counsel, office of General Counsel for NASA here in D.C. I hope to be back by the time you finish with your statement.

Mr. NAGLE [presiding]. Go ahead.

**STATEMENT OF EDWARD A. FRANKLE, DEPUTY COUNSEL, OFFICE OF GENERAL COUNSEL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Mr. FRANKLE. Thank you, sir. Mr. Chairman and members of the subcommittee, I am pleased to testify here, I hope in a slightly welcome change of pace; I am not here to ask for money and what I am here for is to ask for authority.

Mr. NAGLE. We really wouldn't know how to treat you if you——

[Laughter.]

Mr. NAGLE. Can we give you some just so we feel comfortable.

Mr. FRANKLE. I would be willing to take it. [Laughter.]

I am here specifically to discuss two specific pieces of legislation that we think are necessary. The first one is an amendment to the Space Act which would allow the Administrator to prescribe regulations which would authorize NASA to withhold from public release certain technical data that is now already subject to control under the Federal Export Control laws. We believe that this amendment is a fairly small conforming amendment which will complete a process that started back in 1983 or so in order to address an anomaly that existed in the treatment of high technology information that has been funded by the United States Government.

There had been a proposal back in 1983, and I believe it was labeled S. 774, to allow all agencies to withhold this kind of information, and during the debate on that, the Defense Authorization Act of 1984—which I have unfortunately incorrectly labeled in my statement and I would like to correct it on the record, which is Public Law 98-94—allowed the Secretary of Defense to issue regulations that would do essentially what we are asking to do now.

Basically what has happened is there a somewhat Catch-22 between the export control laws and the Freedom of Information Act in that information relating to spacecraft, space electronics and other high technology items that we get involved in a lot—we are in the business of trading that kind of technology, but since we are a civilian agency we don't usually have this in a classified program—it would be available for release to anybody under the Freedom of Information Act including a foreign request or even a foreign government.

However, under the Export Control Act, many of that data would not be exportable without a license. However, since the government agency has a self-licensing capability and we could export it if we felt it was necessary in support of our function, we have discretion to export it. That discretion means we are unable to withhold it under the Freedom of Information Act even if we wish. That type of release under the Freedom of Information Act becomes a publication of the data, and therefore, it becomes available

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to all. And as a net result, information and data that has been paid for by the American taxpayer, which has been developed in many cases specifically for the purpose of helping American industry, becomes immediately available to foreign industry for no investment at all other than a 22 cent stamp and a Freedom of Information Act request.

We believe that our proposed amendment will provide us with the flexibility to address that while still allowing us to continue in our, what we feel is a very aggressive and, as stated in the Space Act, the widest practical and appropriate dissemination of information, to continue our technology utilization efforts which have been talked about already earlier today and I think have been praised, and rightly so.

The other authority that we are looking for in this bill right now is the authority to allow NASA to appoint up to 15 individuals who are retired from either the Civil Service or the military services to be hired by NASA without a reduction from their retirement pay. This is a two-year temporary authority that we are seeking which would allow NASA to attract some highly-qualified competent individuals who otherwise wouldn't come to work for the Federal Government and wouldn't be available because their retirement annuities would be reduced and they would essentially be working for free.

We feel that this authority is needed right now to help us get through the problems following the Challenger accident. We are looking, like I said, just for a limited two-year authority for no more than 15 individuals just to help us get back on track.

I do want to point out that this is not a request which just springs from the blue. Back in 1964 when the Dual Compensation Act was passed, the NASA Administrator was given authority to waive the dual compensation restrictions for up to 30 individuals when he hired them under the other authorities in the Space Act. That authority was premised specifically on the urgent national needs to get the right people in place for the Apollo Program and the space effort that we were undergoing at the time. This is now a critical period of recovery from the Challenger loss and the NASA Administrator needs to have some limited version of that flexibility restored for the current time.

Mr. Chairman, that concludes my opening remarks and I would be happy to answer any questions you or any committee members might have.

[The prepared statement of Mr. Frankle follows:]

Statement of

Edward A. Frankle
Deputy General Counsel
Office of the General Counsel

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Subcommittee on Transportation, Aviation and Materials
Committee on Science, Space and Technology
United States House of Representatives

Mr. Chairmen, Members of the Subcommittees:

I am pleased to be here today to testify on a new section in the FY 1988 Authorization Act.

NASA is proposing an amendment to the Space Act which would allow NASA to prescribe regulations to authorize withholding from public release certain technical data that is now subject to control under the Federal export laws. This amendment would complete a process begun in 1983 to address the continuing problem regarding the export of technology funded by the United States Government that is of significant value to foreign competitors. Although much of the problem was alleviated when DOD was given similar authority in Section 1217 of the FY 1984 DOD Authorization Act (P.L. 98-84), it was recognized at the time that NASA's portion of the problem still existed. The proposed amendment will resolve the remaining portion of this issue. At present, NASA may be required by the Freedom of Information Act (FOIA) to release data that would otherwise be subject to export controls. This FOIA release can be interpreted as a publication, thereby removing the data from any further restrictions regarding its export. In fact, release of this export controlled data directly to a foreign requestor may be required under the Freedom of Information Act; a release which can frustrate not only the purposes of the export control acts, but the Congress' and the agency's technology development goals as well.

We feel the proposed amendment will provide NASA greater flexibility to manage high technology in its possession or under its control in a manner consistent with national policy regarding export of technical information relating to national security. It will also promote accomplishment of NASA's mission of preserving the role of the United States as a leader in aeronautical and space science and technology. It

accomplishes this without cost to NASA's policy and programs while providing the widest practical and appropriate availability of the results of its activities for the benefit of United States industry and commerce. The amendment seeks to accomplish this goal by permitting NASA to promulgate appropriate regulations which will be published after consultation with other concerned agencies.

Let me stress that the requested authority is very narrow and that the technical data subject to this amendment is limited to that which cannot lawfully be exported from the United States without approval, authorization, or license under the current Federal export laws and regulations. The amendment does not apply to technical data not subject to those laws and should not be seen as more than it is: an attempt to resolve a troublesome anomaly in the treatment of the same information under separate statutory schemes. It is NASA's intent to resolve conflicts that exist under present law so that the release of such technical data can be carried out in greater concert with national policy and the national interest.

I would also like to discuss with you our proposal to allow NASA to appoint up to 15 individuals retired from the civil service or the military services without reduction to their retirement pay. This provision will allow NASA to attract highly qualified and competent individuals who otherwise would not work for the Federal Government because their retirement annuities would be reduced.

This authority would be limited to two years from enactment of this Bill and would provide the Administrator badly needed flexibility to bring in some outstanding individuals to fill a few positions critical to rapidly getting NASA back on track.

This request is not without precedent. When the Dual Compensation Act was passed in 1964, it specifically allowed the NASA Administrator to waive the dual compensation prohibiton for up to 30 retired military officers hired under NASA's excepted authority contained in the Space Act. This authority was superseded by the Civil Service Reform Act of 1978. In the current critical period of recovery from the Challenger loss, the Administrator urgently needs to have this flexibility restored.

Mr. Chairmen, that concludes my prepared remarks. I would be pleased to respond to any questions you or the Members of the Subcommittees may have.

Mr. NAGLE. Well, let me take the last one first if I can. Is it going to take a specific statutory authority from the Congress to enable you to bring those 15 individuals onboard?

Mr. FRANKLE. Yes, sir.

Mr. NAGLE. And I assume you have submitted some draft legislation for that?

Mr. FRANKLE. Yes, sir. I believe it is Section 5. No, it is Section 7 of our Authorization Act that was sent up on the 16th of March.

Mr. NAGLE. And now I would like to go to the first one, if I could. I can't speak for the committee but I don't really see a problem with that.

But on the first one, I kind of wonder if you could tie a picture together for me because we had, in one of our first hearings, Dr. Allen in to testify and he released what I think we have termed here the Allen Report, which dealt with the problems that our U.S. companies are having with overly-restrictive regulations on the exportation of technical data. The estimate I think, if memory serves me correct, was a substantial cost in U.S. trade balance; I think $46 billion sticks in my mind, I don't know if that is accurate or not. And somewheres from 150,000 to 250,000 jobs.

Now, how does your proposal here for further restrictions on data release from NASA tie into that, or does it at all?

Mr. FRANKLE. I don't believe it does at all, sir. This would not add any new restrictions at all to the export; the same export controls would apply, and whatever the current policy is would apply to it. It just would say that if there is a policy already in existence which would prevent the export of that data to foreign entities or persons, that they couldn't avoid those restrictions by use of the Freedom of Information Act.

Mr. NAGLE. What kind of data are you talking about?

Mr. FRANKLE. It can be anything; engineering drawings, analyses, descriptions of experiments, manufacturing details. We have had experience, for instance, in one of the programs that I believe Mr. Walker was talking about earlier today that he was in favor of, the ACTS Program, the Advanced Communications Technology Satellite. We have had Freedom of Information Act requests already from foreign groups for the ACTS contract as well, and they have received that, which is a perfectly proper thing. That contracts states, for instance, what the technology goals are as well as a list of deliverables. We presume that as those deliverables are produced and come in with the technical data, the processes all developed, we will get a series of Freedom of Information Act requests for that technical data.

In addition, we have been offered the free use of foreign engineers in the ACTS office to help us come up with this technology, which of course is being funded at U.S. taxpayers' expense. We feel that would just be an effort by the foreign entities to attempt to get the technology that we are trying to develop here.

Recently we have been working the issue since 1983 mostly inside the Administration. Right after the Challenger accident, when the issues came up concerning the critical items lists and what were the critical issues about the Orbiter and the other subsystems of the Shuttle, we had several FOIA requests for the critical items lists themselves. We analyzed all that data, much of

which is very, very technical discussion of what the problem is, how it is addressed, why we feel it is critical, what the design features are that were intended to solve the problem and reduce the criticality and make it acceptable to proceed.

An analysis of the several hundreds of these items showed there was somewhere in the vicinity of 81 which we felt still would probably require an export license. However, there was no way—and we went into discussions with people from virtually all the agencies involved including Department of Justice, DOD, NSC, Department of State——

Mr. NAGLE. Well, the President's competitiveness package, H.R. 1155, contains some Freedom of Information Act amendments which would restrict some releases of information, technical data. How does yours differ from that? I am just trying to get a framework from which to operate here.

Mr. FRANKLE. Well, sir, besides the fact that ours is first and we are further along in the process I think. We do have an urgent need and I think the timing of it is very important to us, especially in light of some of our technology development programs that we have already gotten requests, the start of what is apparently a chain of requests. The provision in Section 10 of the Trade Bill is a flat exemption which applies—just a new one, Exemption 10 to the Freedom of Information Act—it doesn't give any real guidance as to how it is going to be implemented or anything. Ours is a very narrow one, it is limited to us issuing regulations. We would issue those regulations through a public process and in conjunction, or after consulting other agencies. We have a more coordinated approach I think to the issue than would be necessary under the Trade Bill.

I would actually think that should that legislation proceed—and I would expect that will be a lively debate as that bill proceeds—but should that proceed, any agency who wishes to take advantage of that would have to have some sort of regulation or some process. How that would work out through the legislative and regulatory process I don't know.

We have got a much more circumscribed effort, which I think we can get on line quickly and be effective, and if we get the additional authority of H.R. 1155, we would be happy to take that, too.

Mr. NAGLE. One of the things I think we would be concerned about and the committee would want to know what assurances can you give us that the new authority you are seeking to prevent public disclosure of technical data will not impair U.S. companies from having access to information necessary to bid on government contracts?

Mr. FRANKLE. We wouldn't use this authority in any way having to do with how we already protect our data with respect to contractors and our use of contracts. We already have restrictions on some of our data with respect to release to foreign individuals and their use in contracts, and we put restrictions on the data and we do many things which we would continue to do now but we feel aren't overly restrictive, and I don't think we have ever received any complaints from anyone that we have been overly restrictive.

What we would do under this process is I presume our regulations would have some sort of a certification, should we be receiv-

ing an FOIA request, and we would probably maintain some sort of a list of companies that we knew made their money by distributing technology to foreigners. We would put what could then be enforceable restrictive legends on the documents saying that they were not allowed to be distributed beyond U.S. domestic sources. Then once we could do that, we would have some degree of control.

Within our own U.S. uses, I don't believe there would be any noticeable restriction at all. I wouldn't expect it to change any policies whatsoever.

Mr. NAGLE. I guess what we are looking for is to try to do this as cleanly as possible. I mean, you don't want one trade legislation saying one thing and NASA's regulations saying another and then an additional authority saying something else. I mean, you like to keep it as compact as possible. If it is not possible then what you're saying is to join this with H.R. 1155.

Mr. FRANKLE. I would rather keep it with this bill so we could be in a parallel situation with Department of Defense right now, having the same authority they already have through their 1984 Authorization Act. We feel that with respect to the types of technology we are talking about, the space technology, space electronics, we really are in a very comparable situation with them. We have some joint programs such as the Aero-Space Plane, and as we are sitting right now we could be faced with anomalous results.

Should H.R. 1155 become law, I think we, along with the DOD, the other agency that would have similar authority, could work to make sure we did not come up with unusual results from one part of the government versus the other. But right now, our concern is getting something as quickly as we can that will allow us to protect the technology that Congress is funding for the protection of U.S. industry so we don't just have to give it out. Does that answer your question?

Mr. NAGLE. I think so. What you're saying is—if I could recapitulate it—that you don't want to wait.

Mr. FRANKLE. yes, sir.

Mr. NAGLE. That you have a need right now.

Mr. FRANKLE. We have a need right now. We thought back in 1983 we would be getting authority something like this under S. 774, and it got withdrawn during debate because the Department of Defense had received their authority under their authorization act. At the time and on the floor, Senator Hatch stated for the record that he realized that NASA was still left out, basically hanging high and dry, but we could approach that through our authorization process, as did DOD.

That's what we are doing now. I want the problem solved, and if it means doing it—whatever. I don't want to be stuck again in a trade like we were in S. 774.

Mr. NAGLE. Sure, I understand that. The only concern I have is after you read the Allen Report, you realize that we have become so restrictive on what technical data we can engage in trade and release that many of our U.S. companies are finding that they can't sell products to foreign purchasers because of the technical data base involved in the product, and yet they can turn around—the potential foreign purchaser can turn around and purchase it in

Taiwan and get the thing in 30 days. And I just don't think we want to go down any further down that road.

Mr. FRANKLE. I agree entirely with you, sir. As part of the process of getting ready for the Space Station, in international memoranda of understanding which are being negotiated right now we did bring in representatives from several major aerospace companies and industry in general, both big and small, developing companies. One of the things that they specifically requested that we try to put into the agreements and control was the flow of their technical data and technical data we are developing in those programs, to foreign entities so we could preserve the role of U.S. industry.

We have had the experience in the past when we have tried to put that kind of information with those kind of restrictions in international agreements of having the negotiators just smile and say, why bother trying to negotiate that because we will come in under the Freedom of Information Act and get it anyhow. We just think that that is not a good position to be in. We are sort of stuck. We don't have a way to protect the data, we don't have a way to protect U.S. industry. We do understand the difference between the good technology transfer and the bad technology transfer, and I think we are trying to make sure that we don't inadvertently come up with more bad technology transfer than good.

Mr. NAGLE. Very good. Very good. [Laughter.]

Let me go back to one last question on the 15 employees. Can you categorize where they will be working?

Mr. FRANKLE. No, sir. I don't know. I know that the Administrator wants the authority. It's my understanding, he's had difficulty getting the people he has wanted to get in, this is one of the reasons. But I don't know specifically where he would want them to go.

Mr. NAGLE. Or what type of people they are?

Mr. FRANKLE. They're retired.

Mr. NAGLE. Well, it certainly nails it down.

Mr. METCALFE. I think they'd typically be the people reporting to the Administrator.

Dr. ROBINS. Very senior people.

Mr. NAGLE. What kind of very senior people? I mean, doing what?

Dr. ROBINS. A variety of things.

Mr. NAGLE. I'm catching the devil from everybody here, would you tell me your name, please, I'm sorry.

Mr. METCALFE. Ray Metcalfe.

Mr. NAGLE. Okay. And your's?

Dr. ROBINS. Howard Robins.

Mr. NAGLE. Thank you Go ahead. Doing what kind of tests, Dr. Robins?

Dr. ROBINS. Both—I suspect staff and line positions before Dr. Fletcher. The group reporting here sent the record to Dr. Fletcher. The office is below that. It would generally not be serving.

Mr. NAGLE. Okay. That's all the questions I have.

Mr. MCCURDY. Thank you, Mr. Nagle.

I'm also intrigued about the 15. I have gone through this a few times, I hired a retired Colonel Ph.D., Director of Soviet Program with War College and immediately ran into the same problems

with the Civil Service Committee of having to reduce the retirement and some of the benefits which I understand from the one hand how people within the government want to continue to attract new people, and to, certainly, attract minorities and to enhance our recruiting ability.

At the same time, I think it's a little shortsighted to lose some great experience that this Congress could use and other agencies of the federal government could utilize.

And I think it depends a lot, and I think as the administrator goes, it might enhance his position if he were to make some initial—initial evaluation of particular expertise involved. I mean, it's one thing to say that this person is a retired military officer or has been an employee with a particular level of expertise in a technical area or what as opposed to being just a good administrator. There may be a lot of good administrators out there that could be recruited or duplicated; whereas, if it's particular expertise that's short-term and you can't get it any other way, then I think you can make a lot of progress if those are so identified.

I'm—and I say that as no solicited advice. The problem is, I'm not sure that the relevant committee of the Congress is going to buy my line of argument. They didn't buy it with me and I'm not sure they'll buy it in this case. But you would at least have a better case if you went to them.

Mr. FRANKLE. I understand exactly what you're saying, sir. I would like to stress how limited the authority that we're requesting is. It is only for a two-year period, and it is only for up to 15 individuals.

Mr. MCCURDY. Well, I'm not sure, but I—this committee or any other committee other than the Post Office and Civil Service Committee can authorize that exemption. I stand corrected if I'm wrong, but as I understand it they're the ones that have the hold on this, and there's a specific statute requirement that has to be dealt with. We might have to have some guidance ourselves on how to address that.

I mean, it's not us. I mean, if it was just——

Mr. FRANKLE. That's an issue——

Mr. MCCURDY. Those of us sitting up here on this committee or Armed Services or whatever the committee might be, we say, don't wave it off with a brush, but I don't think that's the case. I think there's a—we have some individuals in this body that sit on the Post Office and Civil Service Committee that this is their jurisdiction, and they guard it like no other. And so, it's something that needs to be explored, but that's just from my own experience and observation of how that problem probably goes.

The Freedom of Information Act amendments, that's a tough one. I understand where you're coming from. I work in the classification world, and it gets so bad that even the classifications are classified after a while. And I sometimes resist the urge to classify documents within the Department of Defense and within Intelligence Committee, when in doubt they classify.

There has to be a reasonable balance here. And I think it's important, we need to define what kind of sensitive information we're talking about from a competitive standpoint, from a foreign intelligence standpoint, or even from just a—I don't know what the term

would be, almost quasi proprietary standpoint, as far as our nation goes. And that's—you have a tough fight there.

Mr. FRANKLE. Mr. Chairman, I would like to stress that what we're asking for with that exemption has nothing to do with creating any new type of classification or any new restriction or anything. What it has to do is resolving what I feel is really a small and unintentional anomaly between the two statutes, the Export Control Act and the Freedom of Information Act. As it exists right now, technical data that we developed at government expense—most of our's, since we're a civilian agency is not classified or classifiable, and we don't attempt to do that. But information in programs, some of which were mentioned in here today by you and members of the subcommittee such as the ACTS program, some are being developed for the sole purpose of keeping this country at the cutting edge of technology. It's being done with taxpayer dollars for that purpose.

As it stands right now, once that non-classified technology is produced, even though you couldn't export it without a license—if the company had it, they couldn't export without a license, a foreign government or foreign company can get it for the price of a FOIA request.

I don't think that was what was meant by Congress when they enacted that.

Mr. MCCURDY. Have you approached Don Bonker's subcommittee in Foreign Affairs on this? He's currently writing—I mean, this day, this week, the new COCOM restrictions and the list on the Trade Bill. And I would just alert you to the fact that that train is about nine-tens out of the station.

And that may be where you have to take a shot. You may have to do that very quickly, is what I'm saying.

The other thing is, having chaired the hearings on Computer Security I know where Government Ops is coming from. And when you talk about—mention the Freedom of Information Act, I mean, they literally—they moon walk on the ceiling. And you've got to be aware of those. If it's a NASA bill, that's one thing. But I think what you're mentioning are both Freedom of Information and also COCOM; and you need to look very quickly at those two committees where they're going on that.

Mr. FRANKLE. Well, with respect to the export COCOM, this really doesn't affect that at all. It just uses the guidance of the Export Control Acts as a measure as to what would be covered, and give us some sort of a yardstick to measure whether or not something would fall within that.

Mr. MCCURDY. The yardstick is being shortened this week, considerably.

Mr. FRANKLE. Yes, sir. With respect to the——

Mr. MCCURDY. Do you want to lengthen it?

Mr. FRANKLE. I don't believe.

Mr. MCCURDY. You want to be covered under there—I mean, you want some of the protection accorded that, to interpretation. But what I'm telling you is that, that very definition is going to be highly restricted in the next few weeks. The move is in the opposite direction. The move is to open up trade and to reduce the trend within the Reagan Administration, and that is, of restricting

trade when it deals with national security or whatever the definition might be.

Mr. FRANKLE. Yes, I understand that.

There certainly are much larger issues than just technical data covered by Export Control. There's whole issues of the competitiveness, the commercial useful information. Some, you know, could be somewhat trivial from an export control invention could mean billions and billions of dollars to commercial trade. That, even if it was developed, the government expense would not be within either our right, our ability to control it or that of the Department of Defense at the time.

Our current situation, the fact is we do have a whole lot of information. And a prime example was the information concerning the Orbiter which had to be released under the Freedom of Information Act after the Challenger accident, which would have been subject to control, but we were forced to release it under the Freedom of Information Act. And we felt that that really was somewhat of a compromise of technology.

Mr. MCCURDY. Well, Mr. Frankle, as a lawyer, where are you telling me you need to make the changes?

Mr. FRANKLE. There may be quite a few changes at some point that need to be made. In the short run you have to solve the worse problems you've got; and the worse problem we've got right now is the Freedom of Information Act.

With respect to Export Control data, because it is such a clear anomaly and so easily fixed, it has been fixed through the authorization process in prior years for a much larger problem, which was the Department of Defense in 1984.

Mr. MCCURDY. Any time you mention Freedom of Information Act, then you're jointly referred to the Government Operations, and possibly even Judiciary, I'm not sure, but I know Gov. Ops you are, committee.

Now, it's not a question of finding—pulling a law book off the shelf for the statute. I mean, you have to know who does what around here. And you haven't met a tiger until you met Jack Brooks, the Chairman of the Government Ops Committee.

Mr. FRANKLE. I'm familiar with Mr. Brooks.

Mr. MCCURDY. And have you been before them now?

Mr. FRANKLE. Not on this issue.

Mr. MCCURDY. Okay. Congressman English is the subcommittee that has Freedom of Information. And it would be worth your time to go by and at least explain some of the problem in the near term.

Mr. FRANKLE. Yes, sir.

Mr. MCCURDY. That's just one lawyer to another about that process.

That's all I have. If there are no further questions, we will probably have a few follow-up. And again, we appreciate everyone appearing today, Dr. Robins.

We stand adjourned.

[Whereupon, at 4:36 p.m. the subcommittee recessed to reconvene at the call of the chair.]

# 1988 NASA AUTHORIZATION

TUESDAY, MARCH 31, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 1:50 p.m., in Room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. The meeting will come to order.

The House is in debate right now on the override of the veto on the highway bill so we are going to have a vote at about 2:30. I am going to propose that we proceed, although a number of our members are over there on that debate.

On the subject of the Space Station, I have some opening comments which I am going to defer for a few minutes, as we take a look at a film about the Soviet Space Station that is a Soviet film of which the Soviets refused our request for this film, but we were able to get a copy and you will see that it is not exactly the straight highest quality which will indicate that it wasn't an original copy. [Laughter.]

But the fact is, we have it. So, I wanted the membership to have a chance to see this. It's just a few minutes. To my knowledge, this is the first time it has been shown publicly in this country. Certainly, it is the first time it has been shown up here in Congress.

So, let's roll the video tape.

[Video presentation.]

Mr. NELSON. We will suspend there, having given you a flavor of some of the propaganda stuff coming out of the Soviet Union, tying their quality of life to the future of the Space Station and so forth, and that's what is now coming out of some of the films out of the Soviet Union.

Can somebody flip on the lights?

Today we had previously scheduled to have the mark-up on the NASA authorization, but we decided to postpone that because of the continuing uncertainty and static——[Laughter.]

It's fair to say that over the last months that we haven't made much progress in determining what the intentions were of the White House toward the Space Station. The problem should be clear to everyone. The indecision and the divisions within the Executive Branch that we saw last year following the Challenger have only become more pronounced in the last year. The critical decisions needed in the space program are not being made. The patience of this subcommittee has worn thin, and I know the patience

of NASA has worn thin. The contractors are spending hundreds of thousands of dollars per day, and the patience of a lot of people in America is wearing thin. So it is time to press forward.

Now today we are going to discuss a possible option for authorizing the Space Station that we may consider as part of our mark-up when we have the mark-up of the NASA authorization bill.

Here are the tenets of that approach. It's based on two general principles. First, that the U.S. should have a permanently manned Space Station; not half a space station, and not a useless space station that functions only as a dormitory in space.

Second, the Space Station that we want cannot decimate the NASA budget. In order to serve science, use the space transportation system, and serve as the Agency's centerpiece, all other activities within NASA must remain healthy.

And one proposal is that NASA is capped at a $10 billion level for years into the future, and one of those proposals is that the station would absorb in those years, constantly over several years, four of the $10 billion. You can't preserve space science. You can't use the space transportation system, and do that kind of funding on Space Station with that limited amount of funds for NASA and keep the space program healthy.

Therefore, what we are going to throw out on the table in discussion today is to propose a full multi-year authorization for the Space Station. The commitment that we would make in Fiscal Year 1988 would carry us forward. That would be the commitment, this fiscal year. The annual amount of this authorization would be based on what we judge to be the funding wedge that would be available if all the other space activities are to remain healthy in any given year of funding throughout the lifetime of building the Space Station.

We would expect that the construction development program would last as much as 10 years, and it may be a funding in the range of $15 billion. This, by the way, is about twice what the Skylab cost. Within that funding envelope, we include not only the space hardware, but the ground facilities, the personnel costs, and the marginal transportation costs as well. Thus, there can be no doubt that the authorization that we have in mind would challenge NASA to make the most efficient use of all these elements.

Right now we are having a tough time with the Budget Committee, and one of the things that a lot of the irritation of the Budget Committee members that have been taken out on the Space Station and on the NASA program is their feeling that the costs have gone out of control.

Well, that's why in this proposal our authorization plan involves keeping those costs under control, so that you would have a target cost and that NASA would design to that cost, rather than it being the other way around, where you have a design and you pay for it, no matter what it costs.

Now given the funding realities of the Gramm-Rudman targets, let me suggest to you that that is a much more appealable way in this environment of trying to sell the Space Station in what is an otherwise very cost-conscious Congress. It doesn't say that America's Space Station by the year 2000 is going to be a $15 billion station in 1988 dollars. What it says is that that is the beginning of

which we would multi-year authorize in Fiscal Year '88 to design to that cost, and proceed and get off the dime of uncertainty that we have been suffering under the last year.

Now, the second part of this authorization plan involves operational costs, and so as part of this proposal we would propose that after you get through the development or construction phase, that there would be a general authorization of $700 million per year in 1988 dollars to operate the station.

This again is challenging and NASA would need to find a way to hold down the operating costs, and to make its facility attractive to users who would be willing to provide additional resources. What kind of station might you build within these funding parameters?

Well, we will ask NASA to do what they do best and provide those kind of answers, and they are very inventive and very ingenuous in that.

In other words, we will ask NASA to design to cost under this proposal.

Now three years ago when we embarked on this Space Station initiative, the budgetary climate was far different from what it is today. It was three years that we expected NASA's growth and its budget to be 1 percent real growth per year, and we also expected at that time that the shuttle would generate large revenues which would be additional money available to NASA that it would generate from flying commercial payloads. That would have provided an additional funding wedge of nearly unlimited dimensions and, of course, since then Gramm-Rudman has come into the picture, the role of the shuttle has now changed drastically, and the estimated costs of the Space Station have more than doubled.

So this proposal that we have on the table today is meant as a response to the realities of this present situation. The NASA budget is a concern of a great many this year, and it's going to be for the foreseeable future, and so by bringing stability to the Space Station, we hope that we could convince our colleagues in Congress that this is a program that would merit their support, and that could be done within a reasonable level of resources.

So we have a number of folks to discuss the implications of this proposal. We have Andy Stofan, the Associate Administrator. We also have with us, representing the Office of Technology Assessment, Dr. John Andelin, and he is accompanied by Dr. Ray Williamson.

All right, we will at this point insert opening comments by Mr. Walker in the record.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS OF
HON. ROBERT S. WALKER (R-PA)
SSA HEARING ON NASA FY 1988 AUTHORIZATION - THE SPACE STATION
MARCH 31, 1987

GOOD AFTERNOON, MR. CHAIRMAN.

I WAS SCHEDULED TO MEET WITH THE PRESIDENT THIS AFTERNOON TO DISCUSS A NUMBER OF CONCERNS. MY PRIMARY CONCERN WAS THE PROPOSAL WE EXPECT TO MOVE FORWARD FROM THE WHITE HOUSE LATER THIS WEEK ON THE SPACE STATION.

SINCE THAT PROPOSAL IS NOT YET PUBLIC, I UNDERSTAND THAT NASA WILL NOT BE ABLE TO DISCUSS IT THIS AFTERNOON. BUT THIS AFTERNOON I WILL TELL THIS AUDIENCE EXACTLY WHAT I INTENDED TO TELL THE PRESIDENT TODAY. AND THAT IS, THAT THIS SPACE STATION PROGRAM IS FLAWED.

THE FIRST PROBLEM I SEE IS THAT THE PRESENT STATION PROPOSAL IS FAR TOO EXPENSIVE. THE CONGRESS, AND THE AMERICAN PEOPLE, WERE PROMISED A FULLY CAPABLE $8 BILLION STATION BY 1994. NOW WE ARE ABOUT TO LEARN THAT WE ARE BEING ASKED TO BUY A 15, OR 16, OR MORE THAN 20 BILLION DOLLAR STATION, THAT WILL BE SOMETHING LESS THAN FULLY CAPABLE, AND WHICH WILL NOT BE AVAILABLE UNTIL SOMETIME AFTER 1994.

THE SECOND MAJOR PROBLEM I SEE IS THAT WE ARE ABOUT TO BE ASKED TO MAKE A MAJOR FUNDING COMMITMENT ON A STATION PROGRAM THAT IS

TOTALLY OUT OF TOUCH WITH THE BUDGETARY REALITIES WE MUST LIVE WITH. EVEN AS WE MEET HERE TODAY THE HOUSE BUDGET COMMITTEE STANDS READY TO BRING A BUDGET RESOLUTION TO THE HOUSE WHICH WOULD CUT THE NASA BUDGET BY SOME $1 BILLION. THAT WOULD BE A CATASTROPHIC REDUCTION AND WOULD RESULT IN THE DECIMATION OF MANY NASA PROGRAMS. MORE IMPORTANTLY, SUCH BUDGET REDUCTIONS ARE SELDOM THE ABERRATION OF A SINGLE YEAR. THEY TAKE ON A LIFE OF THEIR OWN BECAUSE THEY TEND TO BECOME THE AGENCY BUDGET BASE LINE, TO BE CARRIED FORWARD IN PERPETUITY. WHAT STARTED AS A BUDGET BASELINE OF NEARLY $10 BILLION SUDDENLY BECOMES SOMETHING LESS THAN EIGHT-AND-A HALF. A BUDGET BARELY ADEQUATE TO FUND THE AGENCY THROUGH ACCIDENT RECOVERY QUICKLY BECOMES A BUDGET THAT WOULD ALMOST CERTAINLY REQUIRE US TO START CANCELLING EXISTING PROGRAMS IF WE MUST LIVE WITH REDUCTIONS OF THIS MAGNITUDE.

THE MOOD IN THE CONGRESS TODAY IS THAT THE SPACE STATION IS IN DEEP, DEEP TROUBLE. THE CONGRESS IS WORKING HARD TO FIND THE RESOURCES TO RETURN THIS NATION TO OUR ACCUSTOMED PLACE OF SPACE LEADERSHIP. WE ARE INVOLVED IN A HIGH STAKES STRUGGLE WITH THE BUDGET COMMITTEE THAT MAY WELL DETERMINE THE COURSE THAT NASA WILL TAKE FOR YEARS TO COME. WHILE THE CUTS IN THE NASA BUDGET ARE BEING PROPOSED BY THE DEMOCRATS ON THE BUDGET COMMITTEE, I WOULD POINT OUT THAT THERE IS STRONG, BI-PARTISAN SUPPORT ON THIS COMMITTEE FOR THE PRESIDENT'S FY88 BUDGET LEVELS FOR NASA.

IF WE ARE TO HAVE A SPACE STATION, AND I FIRMLY SUPPORT THAT GOAL, WE NEED BOLD NEW INITIATIVES THAT WILL SIGNIFICANTLY REDUCE THE BUDGETARY IMPACT OF A STATION ON NASA. WE NEED TO REDUCE OVERALL

COSTS. WE NEED TO REDUCE THE ANNUAL FUNDING PEAKS SO THAT THEY WILL NOT ADVERSELY IMPACT OTHER NASA PROGRAMS. AND, LASTLY, WE MUST ENSURE THAT LONG-TERM ANNUAL OPERATIONAL COSTS ARE NOT EXCESSIVE.

HOW CAN WE ACCOMPLISH THESE GOALS? WELL, THERE ARE AT LEAST TWO POSSIBILITIES WE MUST EXAMINE. THE FIRST WOULD BE TO VIEW A SPACE STATION JUST AS WE WOULD VIEW ANY OTHER MAJOR PUBLIC WORKS PROJECT. WE SHOULD EXAMINE THE POTENTIAL OF SETTING A SERIES OF DESIGN CRITERIA FOR A SPACE STATION SUCH AS:

* FULLY EQUIPPED LABORATORY MODULES
* MAXIMUM COMMERCIAL OPPORTUNITIES FOR PARTICIPATION
* POTENTIAL USE AS A STAGING POINT TO THE MOON AND BEYOND
* ACCEPTABLE LEVEL OF OPERATIONAL COSTS

ONCE WE ESTABLISH A COMPREHENSIVE LIST OF CRITERIA WE EXPECT A STATION DESIGN TO SATISFY, THEN WE SHOULD EXAMINE THE POSSIBILITY OF PUTTING THAT STATION OUT FOR INDUSTRY BIDS. WE DON'T LET DOD OR GSA GO OUT AND BUILD OFFICE BUILDINGS. WE TELL THEM TO HIRE A GENERAL CONTRACTOR. WHY DON'T WE EXAMINE THAT SAME METHOD OF OPERATION FOR BUYING SPACE HARDWARE? JUST BECAUSE WE HAVE NEVER DONE BUSINESS THAT WAY BEFORE IS NOT A VALID REASON TO ASSUME THAT WE SHOULD NOT TRY IT NOW!

A SECOND METHOD WE MIGHT TRY, WOULD BE FOR THIS COMMITTEE TO MAKE OUR BEST JUDGMENT OF WHAT SPACE STATION PROGRAM WE CAN WIN CONGRESSIONAL SUPPORT, AND FUNDING FOR. THEN WE COULD SET THAT RANGE

OF DESIGN CRITERIA, INCLUDING TOTAL CONSTRUCTION COSTS, FUNDING PROFILES, AND ANNUAL OPERATIONAL COST CEILINGS, AND DIRECT NASA TO RE-EXAMINE THE STATION AND COME BACK TO US WITH A STATION PROPOSAL THAT IS SPECIFICALLY DESIGNED TO THOSE COST CRITERIA AND REQUIREMENTS.

THIS COMMITTEE IS WELL AWARE THAT NASA WANTS A STATION THAT HAS BEEN CHARACTERIZED AS "THE WHOLE ENCHILADA." THAT STATION WOULD COST OVER $21 BILLION IN CURRENT YEAR DOLLARS, AND I KEEP SCORE IN CURRENT YEAR DOLLARS BECAUSE THE TAXPAYERS WILL HAVE TO PAY FOR IT IN CURRENT YEAR DOLLARS. I HAVE ONE PIECE OF ADVICE FOR NASA ON THAT PROPOSAL. YOU CAN'T GET THERE FROM HERE. WE MUST LIVE WITH REAL BUDGET CONSTRAINTS AND THE NASA BUDGET WILL NOT SUPPORT THAT PROGRAM AS IT IS NOW BEING PROPOSED.

MR. CHAIRMAN, THIS COMMITTE CONTINUES TO SUPPORT AN AMERICAN SPACE STATION. WE NEED TO MOVE FORWARD. BUT POLITICS IS THE ART OF THE POSSIBLE AND WE NEED TO EXAMINE THE ALTERNATIVES TO FIND SOMETHING THAT CAN BE PASSED THROUGH THE CONGRESS AND WHICH IS SUPPORTABLE WITHIN THE BUDGET CONSTRAINTS IMPOSED BY GRAMM-RUDMAN AND OMB.

Mr. NELSON. Mr. Stofan, did you want to make some initial comments, or did you want to proceed with questions?

**STATEMENT OF ANDREW J. STOFAN, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC ACCOMPANIED BY THOMAS MOSER AND FRANKLIN D. MARTIN**

Mr. STOFAN. I'd like to make a few comments, Mr. Chairman. I would like to enter into the record the very short statement that I have submitted, and I would like to paraphrase just shortly.

Let me take us back to the summer and fall when we established the baseline configuration of the Space Station we wanted to go forward with. We then entered into a six-month costing exercise, and as you know, the baseline configuration had some two years and all the contractors involved, so it was a very well understood program we wanted to go forward with.

And as you know, at the end of this costing exercise, the costs came out much more than had been anticipated, much above the 8 billion. At that time we went back to OMB to discuss it with them. The program then went into the White House to get again the President's approval to proceed. Unfortunately we were—we got involved in a change of administration inside the White House which delayed it just a little bit, but again we eventually did reach an agreement with Office of Science and Technology Policy, National Security Council, and Office of Management and Budget, and those heads of those three organizations and Dr. Fletcher signed a recommendation last week that is in the White House at this time. The status of that agreement, I do not know what it is at the present time.

Mr. NELSON. And the specifics of it, you're not at liberty to discuss; is that correct?

Mr. STOFAN. That's correct, until a decision is made by the President exactly what—if he takes recommendations, modifies them, I do not know what the content of the program would be, so I can't discuss it at this time.

However, as soon as that is released, I will be back with the committee to discuss everything in detail of what is the approved program.

Mr. NELSON. But you are at liberty today to address the comments that I have just made about the proposal?

Mr. STOFAN. Yes, I am at liberty to talk about that. I think one other thing very pertinent to what we just saw with the Russian film that you showed, last night the Russians launched an astrophysics laboratory to dock with their mirror space station, and that will be docked on April 5th. So as we struggle to get started, they are carrying on a very, very ambitious program, and that causes me a great deal of concern.

Mr. NELSON. Do you know any of the particulars of that laboratory?

Mr. STOFAN. Yes. Its purpose is scientific purpose. It's astrophysics, and it also involves European instruments. I know the French have an instrument and some other European nations, so they are building their international station with quite a capability, and as

the days go by, it is being constructed, and I think it's time we get on with it.

At this time I would like to invite Tom Moser and Frank Martin to join me here at the head table. Frank is the deputy and Tom is the program director for the Space Station.

You asked me to address this proposal on the funding profile. There are a number of funding profiles that one could use to support a program. In project management what we try to do is to look at projects, having been doing major projects over a 20-some year period, try to come up with what we consider to be an optimum funding, and that is optimum to do the work, and the funding falls out of that.

Now, as I said, the program we have been looking at over this period of time, we did spend a lot of time looking at it to define HAB, lab modules, the nodes, adequate power, international partners, Canada and Japan, polar platform, and this initial phase could be accomplished with about 16 launches, get first element launch in mid-1994, with permanent manned in 1996. Again, this would start at a funding level in 1988 with our request of about $767 billion. Peak funding would be about $2 billion, and that is the curve that we have shown before.

Now, this program was planned with a lot of thought and care to optimize the way that the work is done, and there is a good reason for this. All the projects that I have been associated with—in fact, I asked my colleagues to think back to was there every a project done that had been tried to be done at a flat level of funding rather than a typical bell-shaped curve, and we couldn't recall any projects run in that manner.

The reason why not is that you bring on board the resources, the analysis, you start out first with preliminary design with a small group of engineers, the engineering staff then builds to design all of the system, and especially on a space station where all the systems are totally interrelated with each other, they must be designed at the same time. You can't design one and then later do another one, or they won't be compatible. So your engineering builds up through your design phase, and all your analyses are conducted. If the structural analysis says you have to redesign your trusses that are being built, that has to be looked at and done right away.

You have to do all your systems at one time and have them come to an end. The critical design review of the station has to occur at a given date, which says then I know that station will go together. That is why the manpower peaks, and it is manpower driven on the cost.

Once you have reached this peak of manpower, you then begin to release drawings to the factory. The engineering manpower begins to fall off and the manufacturing manpower then begins to build up, and the engineers slowly go down less and less and the manufacturing goes up. As the hardware is being produced, the curve then rolls off.

So there is a very good reason why it is shaped that way. It is an efficient way and the only way that I have ever managed a program.

I would like Tom, who is the program director, to say a few words again about why is it that we do business in that way.

[The prepared statement of Mr. Stofan follows:]

Statement of Mr. Andrew J. Stofan
March 31, 1987

Mr. Chairman, the Space Station program has been a major topic of discussion both within the Administration and the Congress over the past several months. I would like to take this opportunity to briefly review with you the current status of this activity.

The cost review which Dr. Fletcher requested in August 1986, has been completed. It reflects a comprehensive analysis of the costs and capabilities of the Station to which he can commit to with confidence.

The program cost review updates the $8 billion estimate which was a preliminary estimate made in 1983. NASA's plan, then and now is to review Space Station data, including cost data, with the Administration and the Congress prior to initiating the detailed design and development phase of the program.

Representatives from the National Security Council (NSC), the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB) together with NASA have held numerous discussions over the past month to understand the new estimates and to explore lower cost alternatives for the Space Station program. The OMB, the NSC, the President's Science Advisor, and NASA have reached an agreement regarding options for the Space Station. This agreement has been forwarded to the President's Chief of Staff for action by the President. My understanding is that a decision will be made early in April.

As we discussed last month, I fully understand that your continued support of the program is dependent upon a complete explanation of the new program estimates. It is my personal intention, Mr. Chairman, that you and your committee will be provided with such an explanation as soon as the President issues his guidance on how the program should proceed. Once this decision is made, I look forward to having an open, frank, and thorough discussion with you and the Committee on the cost, content, and schedule of the Space Station program.

Andrew J. Stofan
Associate Administrator
Office of Space Station

Andrew J. Stofan is the Associate Administrator for the Office of Space Station. He was appointed to this position on June 30, 1986. The Office of Space Station is responsible for the activities required to develop a permanently manned Space Station within a decade.

Mr. Stofan was the Director of the Lewis Research Center in Cleveland, Ohio, from June 22, 1982, until his current appointment.

In 1958, Mr. Stofan began his professional career at Lewis as a research engineer. The next six years included technical research on turbojet ejector nozzles, research on propellant motion in space vehicle propellant tanks, assignment to the original Centaur Project Office as a member of the Propellant Systems Section, and systems engineer for the development of the Centaur propellant utilization system.

From 1966 to 1978, Mr. Stofan managed a variety of technical projects including Head of the Propellant Systems Section at Lewis, Project Manager for testing of a pressurized system for the Centaur vehicle at the NASA Plumbrook Test Facility, Assistant Project Manager for the Improved Centaur, Project Manager of the new Titan/Centaur vehicle, Manager of the Titan/Centaur Project Office, and Director of Launch Vehicles.

On January 15, 1978, Mr. Stofan was appointed Deputy Associate Administrator for the Office of Space Science at NASA Headquarters in Washington, DC. He was appointed Acting Associate Administrator for Space Science on October 14, 1980. He held that position until moving to Cleveland as Director of the Lewis Research Center in 1982.

Mr. Stofan was born in Cleveland, Ohio. In 1958, he received a Bachelor of Arts in mathematics from Hiram College in Ohio and a Bachelor of Science in mechanical engineering from Carnegie Mellon University in Pittsburgh. Mr. Stofan obtained additional graduate hours in math and engineering at Case-Western Reserve University in Cleveland.

In addition to several group achievement awards, Mr. Stofan has received the NASA Exceptional Service Medal in 1975, the NASA Distinguished Service Medal in 1981, the Presidential Rank of Meritorious Executive in 1982, and the Presidential Rank Award to Distinguished Executives in 1985. Mr. Stofan is a member of the American Institute of Aeronautics and Astronautics (AIAA).

He and his wife, Barbara, reside in Vienna, Virginia. They have two daughters, Lynn and Ellen. Mr. Stofan is an avid skier and enjoys jogging and golf.

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Mr. MOSER. I think Andy capped it very accurately. It is basically, especially in the Space Station, Mr. Chairman, as you know it today in the baseline, we have identified those systems which we think will produce a Space Station of balance as far as utility of operations and usefulness to our international partners and also to the users of the Space Station.

The data management system, the environmental control system, the thermal control systems, all those things literally are designed to interact. To design those things in an integrated fashion so that the Space Station has some economies during its development is the reason the characteristic of the spending in the budget looks the way that it does.

If we approached, instead of a design to cost, if we approached a program that said let's fix the rate at something that would not enable us to bring those systems together simultaneously, what we would simply do is we would design those things which we could accommodate the environmental control system and the thermal system. We would complete that and we would set it aside, and then we would bring on the next element of the program. That results in a very inefficient program, probably orders of magnitude of what an optimum program would be.

So that is basically the way we have laid it out. As Andy mentioned, over the years that we have conducted this, we probably have spent close to 10,000 man years understanding a design to cost, identifying the requirements with that, and then establishing those requirements which we think give this balanced space station program, and then what are the costs associated with that.

So we did one complete cycle on that.

Mr. NELSON. Now, what you are saying is that under the work that you have done, that you think that you would need, in those maximum funding years, about $2 billion a year in 1988 dollars. Is that what you are saying?

Mr. STOFAN. Those were 1984 dollars. That is the development program only. That is the other thing. When you started out, you said that we have always talked development program and you added in several other elements into the program that we haven't ever talked about and we haven't looked at. I think you said marginal cost of the shuttle.

Mr. NELSON. I said marginal transportation cost.

Mr. STOFAN. Transportation cost, yes.

Mr. NELSON. That gives you an incentive to look at a heavy lift vehicle.

Mr. STOFAN. And heavy lift vehicle costs a couple billion dollars to fit in with everything else.

Mr. NELSON. It is also saying that America might need a heavy lift vehicle for other reasons, so that is one of the calculations that you might have to look at.

Mr. STOFAN. I don't know what the peak year funding might be. I haven't looked at all the things you have asked. It would be something above the two, but I don't know what it is. Again, we haven't, obviously——

Mr. NELSON. I understand that. We are just throwing this out on the table for a first glance. Now, here you have done an excellent job, Mr. Stofan, and I have been one of the people that has been

quick to praise you, and you have. You are looking at it, and what we want is exactly what you are giving, answers directly related to the station and the station needs and funding.

But understand that our responsibility is that we have to authorize the funding for the entire space program, not just the station. What we are looking at is we have got to have a space program that is healthy, and one of the options that you are talking about, if the NASA budget over the course of the next seven or eight years does continue to grow, then you have got room for growth of the annual funding for the space station.

But on one of those charts that I saw that came out of the administration, namely, out of OMB, it had a 1992 funding for NASA of $10 million. That is less than NASA is being funded in fiscal year 1987, and there is just no way, if you are going to have science that is going to be vibrant, if you are going to continue to use the Shuttle, that you can really start ramping up in one annual year spending on the Station to get way up there.

So what you have identified is one of the variables. If the NASA budget were to go up, as I personally think, if it goes up like it is supposed to, like it was originally intended, one percent real growth, that then you would have some flexibility in there to get at what Mr. Moser is saying.

Go ahead, please.

Mr. STOFAN. I think that, looking at overall NASA, that that is correct. I look mainly at Space Station, but I am aware of all of what is going on with NASA; and looking to the future, I agree with you that it looks like we are trying to do too much without enough money being there.

I look the same way at the Station. You threw out some numbers to consider. I don't want to get the Station into a position that you see NASA maybe getting into in the future. In other words, I don't want to commit to do a station for a given dollar value and say I will operate it at a given dollar value when physically that is not realizable. That is why we have to really study and look at it and proceed cautiously on what are the levels, how high should they be and for how long, and then what we can commit to.

So again, it would take a really intensive study to be able to understand that, like we have done two years of study and the six months of cost assessment. So these things can't be done quickly, and I think that is really what we would have to do to give your idea really a fair evaluation. We may come back and say, well, if you modified it this way or that way, that then we think we could do something.

Mr. NELSON. Okay. What else do you want to comment about? You like the idea of bam, multi-year authorization.

Mr. STOFAN. I think that is a great idea.

Mr. NELSON. Not any phased approach, not any that zaps Johnson, not any that zaps Lewis, not any kind of phased approach that zaps anybody, but says okay, here it is.

Mr. STOFAN. I like the idea of the multi-year authorization.

Mr. NELSON. Do you like the idea about designing to cost, that you know what it is going to cost in 1988 dollars and you go out and do it?

Mr. STOFAN. No, and the reason why is that that is like buying a car that I know what it is going to cost, therefore I get the money and I save it and I go out and buy an automobile. This is a development program, high technology, trying to assemble a station in space like we never have before. A high technology development program cannot be bought fixed price like you go out and buy a car.

We do not know all the technological problems and things we are going to run into, and that is why in a development program we do have such things as reserve, and we don't sign up to a guaranteed fix price delivery on something of high technology like this. And we can't say I guarantee for x number of dollars we can do it. If we could, we would go buy one, and we can't do that.

Mr. NELSON. Now, here we come to a question about what are the resources that are available and what is the political number that we can pass when up until, as far as testimony in front of this committee, up until about a month ago, we were still talking in the range of about $8 billion? So the question is what can be sold?

We have to worry about that, but really, you do, too, because you are the head of the Space Station Program.

Mr. STOFAN. Yes, very, very concerned about that. Just for the record, I don't think anywhere you will find that I said that I could do the program for $8 billion. When I came on board, I said I would make sure technically what we are doing is sound, and then I will go find out what it really costs and let you know. It came out much more costly.

Yes, it concerns me greatly, how can we carry on and do a space station? We looked at a lot of alternatives over the last several months because again, the same thing, the costs came out high. How far can we cut back, what can we delete and still end up with something that is worthwhile?

We have been struggling very hard with this because we know the budget considerations, but I think that we also don't want to cut back to a point where we are building something that the Russians already have in orbit right now or had in orbit several years ago. I think we really ought to regain the technological leadership of the world with a space station that can do the science and technology that we want to do. I think it is extremely important.

As we know, their program is going on and moving and they are going to add several more modules. By the time we launch the first elements of our Space Station, they will be very sophisticated. If we cut back and squeeze down too much, I think we will lose our international partners. I think Europe will tend to go their own way. They have a very ambitious program with an Aryan 5 and a Hermes, and if we start stretching out past beyond the year 2000, I have a feeling they would give serious consideration to going out on their own and developing their own space capabilities. Then it would be the Russians and the Europeans, and we would still be trying to get our own station up.

So this causes me a great deal of concern.

Mr. NELSON. I understand all of that and I really think that, given the fact that the U.S. Space Station is a national research center in space, that as we turn the century, who knows what kind of megaplex it is going to be in space and what kind of science and

technology is going to be coming out of it. And who knows in the year 2020 how much the asset value of this thing is going to be by virtue of the kind of return that we have gotten and are expecting to get at the year 2020.

So it is important that you design something that has that opportunity to grow, but we are dealing in the budgetary realities of fiscal year 1988, so if we have to pick a figure that gives certainty to you of seeing that you have the authorization to go and do the whole thing, then we are going to know what could you build for that authorized funding level.

Now, I know that you personally didn't come on board on this thing until last September, but let me quickly remind you that when this committee did the authorization for NASA's funding for fiscal year 1987 in a request to us by NASA of $410 million, of which this committee authorized the entire $410 million and were given assurances that the vending of the hardware was going to start in this fiscal year, which it has not, that the figure that was given to this committee in the authorization, what was then intended to be the commitment for the United States to go on and build that station and an appropriation of $410 million, the figure was $8 billion.

So we are talking about considerably different figures now, and I am just trying to prepare you, Mr. Stofan. You may well be in a situation that if we are going to have a Space Station—and you know my personal feelings, that I think that it is very important to this country that the dreams stay alive for this country—that the political realities are you may have a figure and you may have to design to that figure.

Mr. STOFAN. I think that you have a national program and a cost figure and it's not impossible to do it that way and that's why I say if we can have flexibility as we carry out the study and working with you, perhaps there is a way to reach closure on it.

Mr. NELSON. Now, for example, if questions came up, you know, about the safety features, in the preliminary thoughts that we have thrown out here, say on down the line you got to a point where you decided there had to be a life boat on the station. All right, now that's not within the proposal that we are making here. You know, if there are safety considerations and you determine that because of the condition of the shuttle, you have to have a life boat onboard, then that's an additional cost.

Do any of the rest of you have any comments before I turn to the members for their questions?

Mr. MARTIN. Yes, I'd like to—Frank Martin. I think there is one thing that concerns me a great deal in looking at the sensitivities of cost and schedule and designing the cost and that is that you understand and we all understand that whatever those caps are in terms of annual funding, that it be something that we can actually deliver a product for on a sensible schedule. If those numbers are too low, then we may find ourselves building a space station in the next century, not this one, and I think that would be a serious mistake, given the kinds of things that you see the Soviets doing that you have shown the people today.

Mr. NELSON. Your point is very well taken, very well taken, and that is something that we would have to be mindful of, everybody.

Okay. I don't have the order in which the members came. Here we go. Mr. Hayes. Mr. Hayes, Mr. Skaggs, then Ms. Morella, Mr. Andrews and Mr. Chapman.

Mr. HAYES. I think one thing that we learned this afternoon is that the Soviets were not cheated at last night's Academy Awards for Best Foreign Film. [Laughter.]

Mr. HAYES. But since we are speaking of them, you made a comment earlier that perhaps our partners would not be too anxious to enter into a build to cost program. Do we have any indication of what our international partners think of the cost elevation, from $8 billion to a figure substantially above that, and whether their willingness to participate at that much higher cost is evident?

Mr. STOFAN. I think the internationals are concerned from the point of view of the increased costs here and the impact that may have upon what the station eventually looks like or how quick we will get it into orbit. Remember, their contribution is a hardware contribution. They are providing a module and a free flyer, the Europeans, the Japanese, a module that is an indoor/outdoor type of thing. So their contribution remains the same to the station and I'm sure they are going to have problems of cost escalation, maybe not like we did, but it will happen to them, too.

So they still want to go with us and their concern is more what is the impact within our own Government of the cost increase of our part of the Space Station, because they are concerned about getting it started and getting going and working with us.

Mr. HAYES. And also if I understand you, we designed—theirs is not a dollar commitment, theirs is a design commitment as well, and therefore, if I understand what you are telling me, change in our design requires a re-thinking on their part for both cost consequences and design consequences. Is that——

Mr. STOFAN. Yes, I think they will commit—provide hardware and eventually operating costs and so their own hardware commitment would remain the same and I think there would be a concern if we allowed the operating costs to go up, then their contributions would go up, so they would be concerned from that point of view, but just the fact that our basic hardware went up in cost is of no direct impact upon them unless we don't do it or we cut the station way back.

Mr. HAYES. Well, it's curious, too. I saw somewhere in the materials on the sizes. What information do we have on the size of the Soviet proposal with all of its components, as to the crew, the total number of crew? I understand it was substantially larger than anything which their present ambition show. Are we privy to any numbers, any estimate numbers?

Mr. STOFAN. Yes, in fact, the mere spacecraft, the size of the module and everything, we have that data. That's been published in Aviation Week and other periodicals, so we have that data. They have 2 to 4 crew. I think the crew up there now is up for 10 months and other long duration stays. They will be bringing up in the next several months other crew members and probably from other nations. They are definitely planning to bring up crew and rotate crew.

Now, as they add more and more modules, they can support more crew. Where that is going to go to in the mid-1990's——

Mr. HAYES. That's really what I am leading to.

Mr. STOFAN. Yeah; our understanding of their program would say they are going to have several modules there at one time, a complex of modules and a crew that will probably be double what they presently have and their program is laid out and moving right along.

Mr. HAYES. The other thing and then I'll turn it back to the Chairman, I noticed, too, we are looking at cost figures essentially back from 1984 and while the comparison to date is fair, we are really comparing apples to apples. In other words, the previous cost estimates, the $8 billion, was that based upon as ambitious a project as has presently been estimated in costs?

Mr. STOFAN. No, not ambitious, not as capable a station, like the configuration at that time was totally different than we have today. That $8 billion was arrived at the very, very beginning of the program when there had been a few 100 man hours spent at looking at a program and it was estimated to be about $8 billion. The station that originally we looked at and today's, they don't look very much alike any more. The station we have today is far more capable, far more responsive to the users' needs.

I think we have tried to be very sensitive to the user community and design—I think the Chairman mentioned—a research center in space where the users want to use it and go to use it and can produce products and make discoveries, so we have been very responsive to the users to design one that is user friendly and meets their needs, much more so than the original design.

Mr. HAYES. So we are not looking at an inflation factor or an error in projecting costs, we are looking at a cost of a different project, albeit under the same overall generic name, nevertheless, it's not the same project that was estimated at $8 billion?

Mr. STOFAN. No, it wasn't, and I think the reason for it and hopefully in the near future I will be able to come back and go into the details, it's a little bit of everything.

Mr. HAYES. Sure, but the point I'm making is when the Chairman talks about justification to Congress, I think that's an important point to be made, that this is not an $8 billion project that became the same project at a much higher cost. It's an $8 billion estimate at an early examination stage that became most costly when a refined project of an entirely more sophisticated nature came into being.

I think that's a point that Congress is not as aware of to those who do not serve on this Committee.

Finally, when these estimates were done in 1984, do you know anyone in the world who would have imagined, for example, just as one example, that superconductor technology would be where it is in 1987 back in 1984? I think that's a point that needs to be made to Congress, that there is research to be done now that didn't even exist in 1984 when these numbers were gathered.

Mr. STOFAN. I think there was a high degree of optimism in the system also about what could be done for what costs and I think the *Challenger* accident has had a direct impact upon the Agency in re-thinking and re-evaluation of all of the great things that we might be able to do to make it cheaper and cheaper and cheaper

all the time. I think we have gone back and re-assessed it, and I'm sure that has had a high degree of influence on the program also.

Mr. HAYES. Thank you. That's a very good point that Mr. Stofan made and the Chairman made a while ago, relative to safety. That is one of the things that we did in light of the recommendations from the Rogers Commission and others, go back and re-assess the program, the $8 billion program, to make sure we shored up those capabilities in quality and safety that we need.

Mr. NELSON. All right. The vote is on the veto override on the highway bill. Mr. Skaggs, you will be the next when we resume and then Ms. Morella. The meeting will stand in recess.

[Recess.]

Mr. NELSON. Let's resume the hearing. Mr. Skaggs?

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. Stofan, excuse me for a second. I haven't got my thoughts quite collected yet.

Are you familiar with the legislation, H.R. 1733, that Congressman Mineta has introduced relative to the assurance of civilian use of any space station?

Mr. STOFAN. I have seen a copy of it; yes.

Mr. SKAGGS. I share some of the concerns that I think underlie Mr. Mineta's proposal that we have a clear idea going in that this will be a civilian science project. I am just wondering if you could educate me as a new member of the Committee about the deliberations within the Agency on that point, the extent to which there are precautions against your becoming an agent of other agencies of the Government in the ultimate uses of the station?

Mr. STOFAN. I'll have Mrs. Peggy Finarelli, who is involved in the negotiation process, explain where we stand. Peggy, would you like to come up? I think she is also collecting her thoughts.

Mr. SKAGGS. I cannot help but be apathetic under the circumstances.

Ms. FINARELLI. In the negotiations, we have made clear to——

Mr. SKAGGS. I'm sorry. I can't hear you very well. Could you move that a little closer?

Ms. FINARELLI. In the negotiations, we have made clear to all of our partners that the station is a civil station. At the same time, we have made it clear that it is a national facility and would be made available to the Defense Department for uses by the Defense Department. We have also made it clear that all U.S. uses would be consistent with the U.S. commitments to the peaceful use of outer space. Those commitments, of course, being in the outer space treaty and the other international treaty obligations that the United States has.

Mr. SKAGGS. And what has been the tenor of any discussions with our potential international partners on this point?

Ms. FINARELLI. The partners have expressed concern about the explicitness of discussions of late. They have also made it clear, however, that they recognize that we have been—that we have made it clear since 1984 when the President expressed his invitation to them, that we have made it clear that the Defense Department was a potential user of the station.

Mr. SKAGGS. Do you anticipate that if we move ahead on this, that there will be some kind of written protocols negotiated with

any international partners that would be more explicit and precise about how we would proceed?

Ms. FINARELLI. There's no discussion about anything along those lines right now.

Mr. SKAGGS. Would you expect that there would be?

Ms. FINARELLI. I don't think so. I think that all of the partners recognize that the international commitment that the United States has to the peaceful use of space under our international treaties is adequate from their perspective.

Mr. SKAGGS. Well, I guess I'm confused. If they are feeling that our treaty commitments are adequate, why are they expressing any concerns at all?

Ms. FINARELLI. I think the concerns are related to the more explicit discussions which have gone on of late. The general commitment that we have to use the station for peaceful uses consistent with our treaty obligations is acceptable to all——

Mr. NAGLE. Will the gentleman yield?

Mr. SKAGGS. Certainly.

Mr. NAGLE. Are you telling the Committee, assuming you are fully informed on this, and that there have not been any objections by the European allies or those objections have been alleviated? I'm referring specifically to the language in Article 3, paragraph 5 which says it can be used for any purposes including national security purposes?

Are you telling us the Europeans have not objected to that clause?

Ms. FINARELLI. No. I didn't say that, Mr. Nagle.

Mr. NAGLE. The truth is they have objected; haven't they?

Ms. FINARELLI. They are concerned about the explicitness of that language; yes. They have expressed concerns about that.

Mr. NAGLE. Have you provided our European allies, if the gentleman will yield further just for a minute, have you provided our European allies with a definition of what that means under Article 3?

Ms. FINARELLI. No, we have not provided a definition of that term.

Mr. NAGLE. Have Article 3 definitions in fact been now drafted and available for inspection?

Ms. FINARELLI. No. There's never been an intention to include a definition of that term "national security" in Article 3. There has apparently been a confusion. Article 3 has the purpose of at the end of the negotiations, picking up terms that are defined throughout the agreement but there has never been an intention to define "national security purposes."

Mr. NAGLE. I thank the gentleman.

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. NELSON. Thank you. Ms. Morella? She will be back in a minute. Mr. Andrews. Mr. Chapman. Mr. Nagle.

Mr. ANDREWS. Dr. Stofan, I really want to commend you for all you have done in the last few months. I think you have done a terrific job.

Mr. STOFAN. Thank you.

Mr. ANDREWS. Let me be sure that I understand kind of where we are right now. You have made a proposal to the White House, to the President, and it is now at the White House.

Mr. STOFAN. Correct.

Mr. ANDREWS. When was that delivered to the White House?

Mr. STOFAN. I think last Wednesday.

Mr. ANDREWS. When are we going to have a decision out of the White House?

Mr. STOFAN. Soon. I hope any day. I don't control what goes on in the White House so I don't know. I can't promise you a date because no one has told me a date but it is my understanding it will be very soon that we will get a decision.

Mr. ANDREWS. Who does control that? Who makes that decision?

Mr. STOFAN. The President of the United States.

Mr. ANDREWS. Okay. Who on his staff is working on this project? Do you know?

Mr. STOFAN. No; I do not know.

Mr. ANDREWS. Are there other proposals before—other recommendations before the President?

Mr. STOFAN. Not to my knowledge, but that doesn't mean there is not. I'm only aware of the one memorandum.

Mr. ANDREWS. You mean there could be other recommendations on space station at the White House now, other than yours?

Mr. STOFAN. I don't think there are but I can't say for sure.

Mr. ANDREWS. Do you have any indication, do any of you have any indication that the President is going to do anything but sign on to your recommendation?

Mr. STOFAN. I don't know.

Mr. ANDREWS. For today's hearing, as I understand it, you cannot testify about what your recommendation is; is that right? They have asked you not to talk about it?

Mr. STOFAN. No. No one has asked me not to talk about anything, but when something is under deliberation in the White House, I feel it would be inappropriate for me to discuss that as long as it is under deliberation. This is my own decision. I have not been told by anyone that I cannot say anything.

Mr. ANDREWS. But your proposal then is probably the only one before the President and that has been, of course, signed on to by Dr. Fletcher?

Mr. STOFAN. That's correct.

Mr. ANDREWS. Your best guess is soon we will know something and you think that soon may be in a matter of days?

Mr. STOFAN. Hopefully; yes.

Mr. ANDREWS. Would you other gentlemen concur with that, that's the indication that you are receiving?

Mr. MOSER. I know nothing other than that also.

Mr. MARTIN. Same thing here.

Mr. ANDREWS. Okay. Let me just ask you about Bill's plan because I think the Chairman's suggestions really have a great deal of merit. It seems that one of the things that has really been troubling to all of us is sort of this feast or famine process in terms of not just space station but almost every other NASA project, the important ones in particular, the big ticket items.

I wonder if you would give us your thoughts in a little more detail about how important it is maybe not to have a static ceiling number every year, but at least to know the caliber of funding that you are going to have for a set period of time. Let me just, before

you answer, pose a problem that I know we all recognize, that there are literally hundreds upon hundreds of contractors out there right now anxious, worried, spending money daily, in anticipation of what this decision may be by the President. Yet, we know that regardless of his decision shortly, we may find ourselves in a similar dilemma 12–18 months from now, 24 months from now, depending on budgetary concerns, and so we go about the construction of the station with this continuing uncertainty about what kind of station we are ultimately going to build, whether or not we are going to complete the darn thing.

As to your potential customers literally around the world, their anxieties are even multiplied and surely are questioning our resolve and commitment to go forward.

Is the suggestion of Bill Nelson worthwhile in the sense that does it not address some of these concerns in the private sector?

Mr. STOFAN. Yes. I think from that point of view, that knowing the resources that you would have available, providing they could be something we could agree to as adequate to carry out the program and having a multi-year authorization were to allow one to plan and carry out the program in a much more efficient manner, as I mentioned, that bell shaped curve, we lay out very, very carefully, where the contractors go out and order long lead parts and material and design boxes and they hire engineers and they bring them onboard, and when you go back the next year and say, by the way, I'm only going to give you half of what I was going to give you, this causes havoc in their companies. They fire people and then go out and bring them back in, stop designs.

It is very disruptive and causes large overruns in the program with the uncertainty of funding. Having certain funding would allow not only the Government but all the contractors to plan their program out, knowing that the money would be coming and it would be a much more efficient way to run the program, provided, with a caveat, that what was there was adequate for the program and we weren't kidding ourselves and just trying to put again 10 pounds in a 5 pound bag, and it just couldn't be done.

That is where my concern is, that we be very careful when we go into this.

Mr. ANDREWS. Well or vice versa, you know, not have enough to put in the bag, and reach a year and a point in development in the program where you need more than that ceiling to be efficient. I think that is what you were pointing out before.

Mr. STOFAN. Yes. I have never run a project where they have given me all the money that was necessary to do it in the proper year, so it would be very enjoyable to do that. You would really have control in the tradeoffs you could make, the design and cost type tradeoffs, what is the best thing and where is the best place to put your money. You would be allowed to make those decisions with assurance that six months from now and a year from now, the money would be there to back up the decision that you made, so it would be an ideal way to run a project.

Mr. ANDREWS. I wonder if I might ask the Chairman of the Committee, how do you address the problem if you get in a year and suddenly you need a big influx of money? You mean, you suggested some safety problems that may arise. Let's say there is an accident.

Let's say there are huge cost overruns in one fiscal year. Let's even say it's not prudent to spend $1.5 in a 12 month cycle.

Do we run the risk of NASA trying to spend it all, you know, to give any of it back. That might be something NASA would think about doing.

How do you adjust for changes?

Mr. NELSON. You adjust, in my judgment, for whatever is the common sense solution that you need. Whoever would have thought that we would have had to have provided an additional $2.1 billion last year for another orbiter? You have to adjust to the situation.

If the gentleman would further yield, here's another point and we might want to inquire of Dr. Stofan. If the rumors are correct, I would say to the gentleman from Texas that this two phased approach that is on the President's desk, if the rumors are correct that in phase two, for example, and therefore cut out in phase one and phase two, if the rumors are correct, there is no certainty of phase two in the space station funding, but in the proposed phase two funding is the co-orbiting platform. If the rumors are correct, you don't even have any certainty that you can go out and design and plan for a co-orbiting platform.

Now, let me suggest to you one thing that this proposal on the table now for consideration would allow. It would give NASA, because they have a dollar figure to which they have to design, it would give them every incentive of what Bob Walker has been talking about for the last two years, and that is to go and engage private industry, such as a Max Faget type of concept, to be the co-orbiting platform and therefore use private industry dollars in that, instead of Government dollars.

That's the kind of incentives that when you design the costs, if that is politically feasible for us to get a figure through, that's the kind of additional incentives you start to get into the situation.

I thank the gentleman for yielding.

Mr. ANDREWS. Thank you for your time, Mr. Chairman.

Mr. NELSON. Mr. Chapman?

Mr. CHAPMAN. Dr. Stofan, let me ask you, if I understand—I don't want to be repetitive or redundant—but I understand perhaps this question has not been asked specifically.

To your knowledge, has NASA ever had a design-to-cost program that has been implemented.

Mr. STOFAN. I don't know, and I'm not sure what design-to-cost—if you mean, has NASA been told, "I'll give you, you know, a billion dollars; go do the program?"

Mr. CHAPMAN. Precisely, precisely. That's how I would define it, design-to-cost.

Mr. STOFAN. Not to my knowledge. I have never been, in 20 years of running projects myself—I have never been involved in one of those, and I don't think that I can recall any in the agency at all.

Tom, are you familiar with any?

Mr. MOSER. Not external. Certainly when it gets down to the program or the project level, that individual is given a cost figure to which he is to design, which is quite normal. And then—then the thing that the chairman asked—encouraged—should be brought into the program, was the innovative ideas of staying within that

design-to-cost, as requirements change and problems occur. And that happens in every program.

So outside of the agency, into the agency design-to-cost, I'm not sure. But down to the implementing of the program, yes, there have been design-to-cost.

Mr. STOFAN. Well, I think that is a good point. I think in all the projects that I've been involved in, you break the project down into elements, deliverable elements—electronic box, an engine, an actuator, an attitude control engine—and you break it down into very, very small pieces that are manageable, and there's a manager put in charge of each one. And you sit and negotiate with him essentially a fixed-price contract for him to deliver to you that element, and he goes off and then does it within that.

If that—if it changes up or down, he comes back in, and you sit down and negotiate. In other words, your're asking him to design to cost, and then track it very, very closely and monitor it, and if there's any changes, changes outside that affect him, again you renegotiate the baseline.

And so you do an internal—and I think Tom's point was an internal design-to-cost, but at the NASA level, I don't think we've entered into anything like that.

Mr. CHAPMAN. Well, that concept would involve, those negotiations, a fixed-price contract, and then somewhere along the way, somebody adds it all up on an adding machine, and you come up with a final cost.

The other way would be working totally from a different direction, and that is determining the final cost, and would force management, then, to, within that cap, work their way down and determine the spending priorities and what would or would not go in that box and how big or little that box would be, based on its priority, necessity, and where it fits within the total concept.

I just—from the standpoint of thinking through that as a way of doing business, as a way of accomplishing a goal—that is, designing to cost—if NASA has given any thought to how that would change the way you do business as it specifically relates to the space station, and do you see any reason why that could not be done, assuming a reasonable figure, that you're not asking the guy to do $10 worth of work for a dollar, but assuming that it is within reason, do you see any management reason why such a concept cannot be implemented?

Mr. STOFAN. No, I don't, and I think your caveat at the beginning, as long as there is a negotiation process between those establishing the number and the receiver of the number, so that they can reach a meeting of the minds on what is a reasonable number and a reasonable amount of reserves into it, then at that time saying, "Look, we'll sign up and commit to doing the project."

Now again, remember these are high-tech development, and if something unusual happens, if there's an explosion or a failure or things like that, recognizing that it would have to be addressed, I think that approach could be taken.

Mr. CHAPMAN. And an understanding as well that one would have to plan for certain failures, I'm sure, in the process. I'm not sure actuarially or from an accounting standpoint how you would go about determining exactly what that cost factor would be, but I

suspect with a little—an analytical approach to it, that could be done.

Mr. MOSER. Can I add to that, Mr. Chapman?

Mr. CHAPMAN. Yes.

Mr. MOSER. That is exactly the way we would do it. Given a program, given a cost and the program being the requirements, given the schedule to go with that, then the Program Manager or the AA or the Administrator has within his capability to vary—if he's going to fix the requirements, and he fixes the date, then he has got to have some type of programmatic reserve associated with a development of this nature, which is technically complex.

Historically, we have established what the reserves are for programs of this nature, to enable us to essentially design to cost with the program requirements defined and the schedule defined. As long as that other variable is there, some programmatic reserve.

Mr. CHAPMAN. If you will, then, assuming that that is a doable deal from the—designing to cost with that number, do you see or perhaps tell me—and not from the standpoint of a minute dissection of the chairman's proposal—but do you see from a management and design standpoint at this point in time why that approach wouldn't work?

Is there some reason, fundamental reason, that that approach would not work as an alternative to what the Administration is considering?

Mr. STOFAN. I think the approach—one thing I mentioned before, the curve, the distribution of a curve to—is the proper way to do a project, or if it wasn't a curve, a level of effort, it would have to be high enough to take that into consideration, and I think if those things could be taken into consideration and reasonably negotiated, I don't see any reason we couldn't pursue the idea further, then.

Mr. CHAPMAN. Do you see any reason why to pursue such an idea would consume perhaps any great period of time, why that couldn't be done perhaps within a timeframe that the program moves forward, moves forward now?

In other words, I suspect there may be strong sentiment on this committee and perhaps in the Congress for that approach, and do you see any reason why that would slow down the process?

Mr. STOFAN. No, I don't see any reason it would slow it down. There is no reason that could not be done in parallel with what's going on.

Mr. CHAPMAN. All right.

Mr. STOFAN. It would not slow down the overall project.

Mr. CHAPMAN. I just simply would like to echo what Mr. Andrews said, Dr. Stofan, in the hard work, and I know it's been immensely difficult, and let me say that to the other witnesses as well.

We appreciate the work you're doing. This committee supports where you want to go, and we hope we can work with you and determine the best way to get there.

Mr. CHAIRMAN, I appreciate the role you're playing in this and hope we can be very constructive in working these problems out.

Mr. NELSON. Mr. Andrews, it's a delight to have you back. You are welcome here anytime.

Mr. ANDREWS. Mr. Chairman, this is much better than welfare reform; I want to tell you that. [Laughter.]

Mr. NELSON. Well, you are welcome anytime, and you're a valuable resource and dear friend and good advisor to this committee, and we appreciate your counsel.

Before I call on Mrs. Morella, you basically have four alternatives, four variables, as you look to the future of how you fund this thing. There's the rate at which you ramp up. Another variable is the peak in any year in funding. Another is the rate at which you ramp down. And the fourth variable is the time over which the spending occurs.

Now do you want to give us a little comment with regard to those four variables, with regard to this proffer that's on the table?

Mr. STOFAN. Yes, there is—as I mentioned earlier, there is an optimum way to do a program, of ramping up, bringing on the manpower, doing the design, going into the construction, delivering the hardware, and then launching it. There is an optimum to do this and to plan a program and to run a program. And it turns out that that optimum way does produce costwise, expenditurewise, a bell-shaped distribution curve, and once you go into it and try to force some other monetary curve or line upon that, then you're causing disruption. It causes you to do business in a way that you would not normally do, and it would be less efficient, which means in the end you would spend more money.

So we have to be very careful about taking away from a program or doing it in an optimum way and say, "Well, I'm going to do it in a different way," because different begins to change the costs, because the reason it's done the way it is, is for technical reasons, it's the proper way to run and a proper utilization of your men to bring them on the program and get them off. If you have a level of effort over a period of time, the men get on the program, and they don't get off, and so it becomes very, very difficult to manage.

Mr. NELSON. Well, it's interesting that you say that, and what you say is absolutely accurate, and that's the way to get the efficiencies, and it's interesting that you say that, because the very proposal that lies on the President's desk, which you can't talk about, with that Phase 2 approach, does not give you those efficiencies through that optimum.

As a matter of fact, you start out, if you got that authorized, with only a half a loaf, not knowing that you're going to get the rest.

And so what we're trying to do is at this point in the uncertainties of this time, look not at the optimum, but look at what is affordable and considering those four variables.

Now it doesn't say, Mr. Andrews, by the way—and, Mr. Chapman, to your question—it doesn't say that four years from now, you don't change. I mean, something may well have happened in four years that changes what you want to design to or changes even your commitment for your overall cost.

The flexibility is always there. This is right now saying, "This is what we're going to design to."

Mr. Andrews?

Mr. ANDREWS. Yes. I think you're right. I mean, I think there are some problems with it. And I think being flexible with what you suggest is going to be difficult. That's going to be a real test.

But surely the way we go about this process now deserves a change, and surely what Space Station thus far has taught us is that we've got to make some changes, because we are doing just what you suggest; we're involving the private sector in a major way in the construction and the development of the program.

And I think this feast-or-famine kind of budgetary process does not work that way, and if we're going to be competitive with our trading partners and our adversaries around the world, we've got to have a more consistent funding mechanism than we've got right now. We've got to make some of those changes.

So I see some problems with it. But, Mr. Chairman, I think that on the whole, it's surely worth trying. It's surely worth the debate and the discussion, and I really commend you for coming forward with it, because we've just got to somehow instill some confidence in this program in the private sector.

Mr. MOSER. Mr. Chairman, if I might add a comment on two of your variables.

Mr. NELSON. Certainly.

Mr. MOSER. One is what the peak is, and one is the time variable. Depending on what that peak is, obviously that's what the time variable is derived to be. Given a peak that is such that you cannot bring on the necessary elements of the program, it stretches out the completion a tremendous amount. So there is a very critical balance between what is the peak and what is the time at which you want to complete.

I would submit that if you take an optimum program, be that what it is, and cut that peak in half, the schedule does not necessarily go out by a factor of two. It may go out by a factor of three or four, because of the bringing the necessary elements together simultaneously.

So that's a fine balance. I think everyone is saying we certainly think we could do something like a design-to-cost, and we can work with a buildup, and they come off the program, provided that the peak of that program and the duration of the program is correct.

Mr. STOFAN. I think one of the other variables not mentioned is program content, that we have to end up with a usable, worthwhile Space Station that again shows our technological leadership. So that's another point, and all those have to go together to take forward a program that's sensible.

Mr. NELSON. Well, can you do that for $15 billion?

Mr. STOFAN. With all of the elements that you said before?

Mr. NELSON. As a starting point, yes.

Mr. STOFAN. The answer is, absolutely not.

Mr. NELSON. Well, then, we have a disconnect someplace. If last year, that NASA comes and says, "We want a Space Station for $8 billion," and you—in fact, we commit the money into what we thought was the beginning of that Space Station, and now NASA is responding to my question, "Not $8 billion, but $15 billion," and you say you can't do it—we've got a funding problem.

Mr. STOFAN. Remember, the content of the $8 billion was the development cost of the Space Station alone. What you have done is

added in a lot of other elements of infrastructure that wasn't in the 8 and is not in the 14.5 for the full-up station. It's not in either of those numbers, and you're going to add in all that, and what you're doing is, you keep putting things into the bag, and 15, the bag isn't big enough for all the things you want to do with it. We cannot do that for $15 billion.

I've taken a quick look, and that's very easy to see that that cannot be done.

Mr. NELSON. Well, if I had a magic wand or if I had an unlimited money tree, then our jobs would be easy here. But what we are looking at is, out of this Administration's OMB telling us that in 1992, that they're projecting that all of NASA is only going to have $10 billion of funding, and there's no way that you can squeeze a Space Station that is going to cost in excess of $15 billion—or to put it in your words, "Absolutely not can I build a Space Station for $15 billion," end of quote, there's no way you can squeeze it into that kind of budget.

Now every one of us on this committee don't think that a $10 billion NASA budget is realistic in 1992, but that's what we're having to deal with.

Mr. STOFAN. Yes. I want to make sure that—people often quote you and I from this committee—the $15 billion has in it the shuttle elements, et cetera, et cetera. It's not just the development. I think you've got to be very, very careful for—you and I—I think you and I understand what we're talking about, but others do—the $15 billion had in it about five different elements that are added to everything—anything that I've ever talked about before. So there's no relationship between that 15 and the Space Station we've been talking about.

Mr. NELSON. Yes, that one—just so the record is clear, one of the things that we suggested that is included in these costs, to give NASA the incentive to hold down the marginal cost on the transportation—we're talking about marginal cost. If you decide to put it up by the Space Shuttle, then it's the marginal cost of that additional Space Shuttle flight.

On the other hand, NASA might determine that it's in the interest of the nation to have a heavy lift vehicle that might drive costs down, marginal cost of going into space and putting the Space Station up. Therefore, it gives them the incentive to look at that option, which otherwise you do not have.

I am sorry, Mrs. Morella. I got diverted here and forgot to call on you.

Mrs. MORELLA. Thank you, Mr. Chairman.

I want to ask you, as we talk about the Space Station and what can be accomplished there and the need for it, are there some material science benefits that would accrue from a space station? If there are, would you mention what they are?

Mr. MARTIN. Yes. We have had quite a bit of activity going on in the material sciences area. NASA has a material sciences program in the science and applications area. Bert Edelson is the head of that program. We have had a number of studies going on looking at things that we could do, and at the last hearing we talked about some of those, such as development of alloys, growth of crystals, gallium arsenide, things of that sort.

There is also some medical pharmaceutical production that falls in the area of microgravity-type research that we also consider doing. So there are a number of things that are around or available. There are a number of companies that are interested, and we could certainly provide you more detail if you would like.

Mrs. MORELLA. I would be interested because we don't hear that much about it, and I would like it very much.

I wanted to ask you if you could explain something else to me. The expression "downselect of contractors" and how the authorization that was discussed today that we placed before you, how it would affect your ability to accomplish a downselect of contractors with that proposal. Would they be able to help with the design-to-cost approach?

Mr. STOFAN. Downselect means that we have the contractors submit proposals, we evaluate the proposals and then select a contractor for the full development of the Space Station. That is the process that we are trying to get started. We haven't been able to release the RFPs yet. As long as what you are buying in the future is what we are buying today or something similar to it, there would not be a problem.

If the design-to-cost number were such that it would drastically be something totally different than we have today, then we would have to go back and start out all over again to define what is it that we are trying to get. For instance, the $15 billion, adding all the Shuttle transportation costs, et cetera, construction of the facility and several other things into the number that was never there before.

A quick look at that says that we cannot design a station, any station that I know of, for that amount of money with all those things in it. If I were going to ask the contractors to try to do that, we would have to go back and start all over from scratch because there is no such permanently-manned station that I can foresee being done for that.

But as long as we stay and end up with something near that we have been proposing, then there wouldn't be any problem with proceeding along with the RFPs and awarding the contract. In fact, in the proposals we are asking the contractors to submit innovative ideas to reduce the cost of the station, so we are soliciting that and also looking for commercial partners, commercial application of the station also.

Mrs. MORELLA. Do they invest themselves, as they make their presentation? It is a personal investment on their part, isn't it?

Mr. STOFAN. They are spending—I was told a number but I haven't verified it—about $800,000 a day being spent, sum total of all our contractors, and we are not paying for any of that. That is coming out of the companies. So the personal investment is going on every single day as we wait to release the RFP.

Mrs. MORELLA. So you don't feel that they would lose incentive by the design-to-cost approach?

Mr. STOFAN. As long as the numbers were reasonable and our concerns could be taken care of, no, I don't think so. If there was a number and we said that's the number you are going to get, go do it, I think there would be concern on everybody's part, but if we

can negotiate together as reasonable partners and arrive at a conclusion, I don't think that would be a problem.

Mrs. MORELLA. Finally, do you think that there will be a budget when the administration approves the Space Station that will accompany it that we will learn about, a recommendation?

Mr. STOFAN. I would expect to bring back to Congress a program and a budget and a schedule and a content and be back with you in the near future and discuss all of it as a package with you.

Mrs. MORELLA. You think a decision will be made this week by the administration?

Mr. STOFAN. I hope one will be made this week. I think it will be soon, but again, I obviously don't control that process.

Mrs. MORELLA. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. Earlier in response to Mr. Andrews, I believe you indicated the Space Station is totally a creature of NASA and OMB and was submitted to the administration as NASA's proposal. Did I understand your testimony correctly?

Mr. STOFAN. I said that NASA discussed the increased costs with the OMB. The NASA Security Council and the Office of Science and Technology Policy were asked to also take a look at the reasons for the cost increases and to work with OMB and NASA to come up with a recommended program, and the leaders of those four organizations signed a recommendation that was delivered to the White House.

Mr. NAGLE. Now, can you explain to me? There was some rather protracted negotiations involving a number of government departments from last September through—I believe they were concluded just before Dr. Fletcher's first testimony in front of us with regards to the uses to which the station would be put.

Mr. STOFAN. That is negotiation on the international governmental agreement in the memorandum of understanding. That is a different group than the ones that are looking at the cost and the program content. Those things are totally going on in parallel.

Mr. NAGLE. Okay. That is what I was curious about. Are they interrelated?

Mr. STOFAN. They would be if the process came out with a totally different station that could not accommodate the international partners. Then they would be interrelated. I think most of the things that have been under consideration would preserve the international partners, and it would only be that if a decision came out that the international partners' ability to participate was somehow hindered by our decision, then it would affect the other agreements, but otherwise it would not.

Mr. NAGLE. I think we have already established, unless I am mistaken, that some of the distinctions that the other group made in terms of international partners' cooperation, specifically Germany, that they have deep reservations about some of the proposed uses of the Space Station.

Mr. STOFAN. I think that there have been some reservations expressed at high levels because of the language that has—again, I think the specificity of the language that is in the proposals, but again, that is a very high level. I think the other nations, of par-

ticularly ESA, are anxious someday to have independence in space, and I think there is no question about this. They have stated that. I think there are considerations of when they go do it. So negotiations aren't being jeopardized by one little thing. I mean these are very, very complicated negotiations with them, and they are looking at it with their national interests.

Mr. NAGLE. I didn't ask about the other things, but I said it is fair to say that that language that I made reference to earlier is hampering international negotiations in terms of European cooperation; is it not? I specifically mentioned Germany.

Mr. STOFAN. The answer is yes.

Mr. NAGLE. Okay. Now, when you submitted these proposals to the White House, and I know you can't tell me what they were, but were the status of those negotiations—let me ask you in a different way. In the recommendations to the House we are going to see, I think I understand, on Thursday, are there two types of programs, one with European involvement and one without the European involvement?

Mr. STOFAN. No.

Mr. NAGLE. Does the cost that will be submitted to us—I know you can't tell me what it was—include the anticipated European cooperation?

Mr. STOFAN. I anticipate that we will bring back a program to you that includes the international partners.

Mr. NAGLE. As a portion of the cost of construction?

Mr. STOFAN. They contribute elements to us, hardware elements, laboratories to us. It is not a part of the cost of construction. They are delivering a piece of hardware, a laboratory, the Europeans, and a free flier polar orbiter to the program. That is what the agreements are being worked on.

I think I am missing your point.

Mr. NAGLE. Yes, I think maybe you are. When we get these proposals from the administration, are they going to include a space station with European cooperation as part of the cost?

Mr. STOFAN. I do not want to talk about it. It is getting back into the content of what is going to be in the proposals and what is not, and I don't——

Mr. NAGLE. Well, did your recommendations to the administration include that anticipated European cooperation? I think you have already said yes to that.

Mr. STOFAN. The recommendation included the international partners, yes.

Mr. NAGLE. And I apologize because we were doing some hearings over in the Agriculture Committee and I wasn't here earlier. In the cost that you submitted to the administration, does it assume that the entire station would be built by Shuttle launch or did it include heavy lift launch?

Mr. STOFAN. The station, all the versions that we have ever looked at of the station, investigations that we have made have been with the Shuttle for assembly because that is the only vehicle that exists to put together a space station, and I could not go propose to someone that I put together a space station with a vu-graph launch vehicle.

Mr. NAGLE. Okay. Now, you are saying that if we had a heavy lift launch vehicle, it could not be used in the construction of the Space Station? You are not saying that, are you?

Mr. STOFAN. I'm not saying that at all. I can't base a program on a non-existent launch vehicle.

Mr. NAGLE. Are you prepared to present to us the alternatives if we have a heavy lift launch vehicle?

Mr. STOFAN. Yes. We have studied the use of ELVs, expendable launch vehicles, and we have run two studies now on heavy lift launch vehicles, so we are making studies and looking at these things and evaluating as we go along that if there were one, could we use it, and I would be able to discuss that type of thing with you when we come back with a program.

Mr. NAGLE. When you come back with the White House's recommendations.

Mr. STOFAN. Yes.

Mr. NAGLE. And did you also look in the preparation—I am just trying to get a framework for when we go forward—did you also look at, assuming we have heavy launch vehicles, the rapidity with which this could be constructed, the station?

Mr. STOFAN. We looked at if we had expendables, what would be the impact, and if we had a heavy lift, what would be the program considerations of that. We will be able to discuss that.

Mr. NAGLE. I can assume, can I not, that the recommendation we will get will dovetail in, the recommendation we will get on the cost of construction of it, will dovetail in the earlier discussions with the Department of Defense and the National Security Council? That will be part of what we are building? I mean their considerations from those early parallel meetings will be taken into consideration in your recommendations? Would that be fair?

Mr. STOFAN. Those are two totally separate processes.

Mr. NAGLE. Tell me why.

Mr. STOFAN. The agreements that are being negotiated, especially the intergovernmental agreements which are now under consideration, have the inputs from most all of the elements of the U.S. Government. The agreements are at the intergovernmental—again, these are at the State Department level, but the rest of the elements of our government look at these agreements and comment upon them and get their comments into them when it is negotiated. That is that process that is going on.

The process that is going on with coming up with a proposed Space Station and the amount of money it takes and how long and what is the content is a separate process and——

Mr. NAGLE. Doesn't content include use?

Mr. STOFAN. It includes the configuration of the station.

Mr. NAGLE. What you are going to use it for? Isn't that included in content?

Mr. STOFAN. The use is implied by the configuration, yes. Sure.

Mr. NAGLE. Okay. So naturally—I would be surprised if you didn't do this—but naturally what you are going to include in content is what the Europeans and the other intergovernmental agencies have requested when you come to us with a cost figure, are you not?

Mr. STOFAN. That is a consideration, yes.

Mr. NAGLE. I would like to join the committee in congratulating the chairman, if I can get his attention. I know, Mr. Chairman, when praise comes so frequently, it sometimes becomes accepted, but I would like to congratulate you on breaking through the log jam on this issue and giving those of us who want a station, for whatever use and whatever purpose and with whatever restriction, I would like to congratulate you on at least breaking the log jam and getting us here today, and maybe we can move forward on this very valuable endeavor.

Mr. NELSON. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

I too would like to congratulate you for at least trying to get us out of the mine field that we find ourselves in. I think your proposal is, in fact, something that needs some serious examination in moving toward that end, and I particularly appreciate the fact that it does reflect some concern about maybe some of the commercial options that can be looked at in the future.

But I must express some reservations, too, reservations that grow out of the NASA proposal, as well. It seems to me that one of the things we now recognize went wrong in the Shuttle program was that early on we decided that we could figure out ways to do it for less cost, and we in the administration and the Congress ended up designing a vehicle that was less than what it could have been because we began to move down this road of designing based upon what we thought the budget arguments would be.

What that leads me to is to say flatly that the government resources available for the Space Station are those which are reflected by the chairman. Anybody who thinks there are going to be more government resources available for this vehicle than what the chairman has indicated simply hasn't looked at reality.

So if we are, in fact, going to rely purely on government resources, the chairman's proposal is probably the only one that has any chance of flying whatsoever. That does lead us to the problem that perhaps we will design a station which is less than what it should have been and less than what it could have been, and that bothers me.

What I want to explore with you is whether or not there are some ways of getting some additional resources into this station that are not necessarily government resources, thereby increasing the amount of money that we have available to the station that goes beyond just international partners.

Let me first of all ask this. When we flew Skylab, wasn't one of the proposals that was shown to be technically feasible in Skylab to basically fly a wet station and build essentially a configuration in space based upon the wet module?

Mr. STOFAN. I hate to say it, but that was before my time. I honestly don't know. I am not that familiar with the early days of that program. I think that was a consideration, but I do not have the specifics or the approach with that, Mr. Walker.

Mr. WALKER. Surely Skylab is a model that we are going to look at in terms of building a station, isn't it?

Mr. STOFAN. A model? No. What do you mean by a model?

Mr. WALKER. Well, some of the experiences that we had in Skylab and some of the things that we looked at in terms of put-

ting a Skylab into orbit, which was at least a primitive space station, surely will help and guide us as we move toward designing this space station, won't they?

Mr. STOFAN. Many of the people involved in the original Skylab program at Marshall and Johnson are involved in the space station program today, yes.

Mr. WALKER. What I am told is that one of the things that we showed was feasible at that time was to essentially launch a wet module and to provide it with the necessary things for sustaining human environment in orbit. What that leads me to is isn't there some feasibility in using the external tanks from the shuttle as a way of providing us with a very, very large capacity for a space station?

Mr. STOFAN. Number one, we don't need a very, very large capacity. The size of the modules that we have today are plenty—they are large enough to carry on the research that has to go on in them. And again, there have been some looks taken, and Tom may want to say this, that you don't get anything for free. There is no free ride. If you take up an external tank, you have to get it into orbit, and then when you get it into orbit, you have to go inside of it and haul up all the material with a shuttle flight and provide propulsion, provide attitude control and everything to keep the tank in orbit. Then you have to have people build it in space rather than build it here on ground.

When you start looking at all this, it does not appear to be any great thing that is going to save you a lot of money. Tom, you——

Mr. WALKER. I understand what you are telling me on that. On the other hand, in order to get a lot of people interested in perhaps investing in this, we may need a lot more capacity than what you are presently planning. So what I am asking here is whether or not there aren't some ways of providing a lot of capacity in orbit by maybe using the external tank.

Mr. MOSER. Let me comment on that. The external tank, following your idea there, could theoretically be used as the pressure vessel to house people in space. The expense of the Space Station program or the systems that go in that pressure vessel—the pressure vessel per se is not a very expensive portion of the program, so there we would have on orbit an external tank consisting of liquid oxygen and liquid hydrogen remaining in it that would have to be purged. It would have to be designed to be able to be accessible. It would have to have provisions added to it to accommodate life support systems, data communication systems, environmental control systems.

It would have to be literally outfitted in orbit. I would be very, very surprised if there are any economies realized out of that. The pressure vessel—you know, it is the tail wagging the dog in a case like that.

Mr. WALKER. I understand that point, but my point is this. Isn't it logical that we might ask people who are going to do things on orbit to provide the money and to provide up front the capacity needed to do the things they want to do? So therefore, instead of government providing it all, we would, in fact, provide the pressure vessel, we would, in fact, provide a few of the things that are needed, and then ask other people who want to do industrial work

or want to do laboratory work or want to do a variety of things to provide the money that would provide the facilities aboard that pressure module, and that we would have sufficient capacity there with which to do those things.

I am not saying it would end up being cheaper. I am not saying it would end up being less expensive. It may well end up being more expensive to do it that way in total, but we in the Congress would not have to provide all of the funding that way.

Mr. MOSER. Your concept is not too different than the concept for the Space Station program now. We are providing a facility that has some capability in power and environment so people, so commercial endeavors, so scientists, people around the world can provide the things they want in that habitable volume.

Mr. WALKER. Well, let me ask you about something else. Wouldn't it seem logical that if we, in fact, told someone that we were going to buy the power that they could generate in orbit, that there might be somebody that would be willing to build a satellite of some sort, a power station of some sort that would provide the power for a space station and then would get their money back, would get back the money that they invested by what was earned by us purchasing power, and then they would go out and look for some other customers as well? That would relieve us of the need to fund up front all of the monies needed to provide power about the station. Someone else would put up the investment dollars.

Isn't that something that might be a possibility?

Mr. STOFAN. We have already taken that into consideration and we have issued guidelines for commercial development that constitute a policy saying that indeed we will consider things like that. In the RFP we have asked our contractors to go out and find commercial types of things that they can bring back into the program. We are working on an MOU with Max Faget to have him be part of the Space Station.

We are encouraging commercial endeavors and commercial partners in this across the board, and so far, besides Max, no one has come forward and offered to do anything like that. We have it as a policy, and yes, we are right along with what you say. It is a policy, and yes, we will consider anybody's ideas.

Mr. WALKER. I understand that you have looked in that direction, but I don't think you have issued a policy guideline. Until you tell someone that they, in fact, will be the sole source of power, you really don't have any kind of investment opportunity for anyone out there. As long as someone thinks that you are going to get power from other sources and that you simply are looking at this as an option, the chances of getting someone to invest in that are not very good.

If you tell someone that they are going to be the utility monopoly in Earth orbit for a period of time and at some cost factor, then all of a sudden you will get investors interested. I don't hear that kind of thing being done. What I am suggesting is that if we are going to get resources from other places, we will have to look toward extremely different concepts than what we have looked at before, some of which are going to involve someone other than NASA building the Space Station.

I don't see anything in any of the plans that have come across my desk that suggest that you have been willing to go that far in exploring some of those options.

Mr. STOFAN. The answer is yes, we have, and if we have not gotten that policy to you, it's too bad we haven't. The policy is NASA Guidelines for United States Commercial Enterprise for Space Station Development and Operations. This is a set of guidelines and policy that I have signed off.

NASA welcomes and encourages participation in space station development and operations by U.S. commercial enterprises which seek to develop with private funds space station systems and services. NASA will entertain proposals for commercial development and operation of space stations systems and services with the goal of achieving negotiated agreements between NASA and the enterprise.

Agreements shall be for specific services with the responsibility and interfaces clearly defined and shall be focused on achievement of objectives in specific time periods. NASA will provide where appropriate incentives to the enterprise.

We have an entire policy that states exactly what you are saying. I will get you a copy of it. Maybe you haven't seen it.

Mr. WALKER. But the design that you have at the White House or the design that we are talking about here, do either of those contemplate providing no power aboard the station and buying all the power from a commercial vendor?

Mr. STOFAN. In any of the proposals that we have considered for, it is that the U.S. Government will provide the entire power for the Space Station because no one has come forward anywhere with any idea or any money saying they have even the slightest interest in doing anything like that.

Mr. WALKER. What encouragement have we given anyone to suggest, other than putting out some guidelines? What encouragement have we suggested to anyone? Have we ever talked to anybody in terms of what kind of money we are willing to pay for power aboard the station? Have we ever sat down and talked to anybody that might be able to build that kind of capacity and suggested to them that we might be willing to pay up to $100 million a year for that power?

Mr. STOFAN. No; I haven't told them we would pay $100 million or any——

Mr. WALKER. I don't know what the figure is, but it seems to me that all of a sudden you would get a good deal of interest if they thought you were willing to pay a significant amount of money on an annualized basis for the power that the government used aboard the Space Station, and then when they realized that there were some commercial operations that would also buy that power from them——

Mr. STOFAN. There is an assumption on your part that I think may be true or may not be true, and that is that the people are lined up out there waiting to come and build a system in space to provide power for us. I think that assumption may not be true.

Mr. WALKER. It may not be true. I guess my problem is that at a time when we have a resource crunch, I don't see any innovation being undertaken toward trying to get us out of the resource crunch other than trying to figure out a way to finagle the budget further so that we can build what we want to build the way we want to build it.

Mr. STOFAN. Also, I would not bring to Congress a program saying I'm bringing half a program to you, and I can't get it into orbit and it won't work and it is not going to apply; however, there are going to be other people that are going to jump up and supply the other half of that Space Station. I think it would be a bit irresponsible on my part to try to do that, also. What I bring to you has to be something that is doable and something that is real.

Mr. WALKER. We have discussed this before, but it always amazes me that every time that I see every artist's conception, every model, every detail about the Space Station, all of them always look exactly like the latest thing I have heard from NASA, which is their version of the Space Station. I never see any innovation from anybody. Everything always looks exactly like the latest version of the NASA Space Station. I have to believe that is a little more than coincidence.

Mr. STOFAN. Maybe it is the right configuration.

Mr. WALKER. Well, it may be, except that it is changed all the time. I mean at the time that you were talking about flying a power tower, everybody had a power tower. When you wanted double keel, everybody had a dual keel. I mean everybody always has the station that you are promoting at that particular time. My guess is that they are doing so because they believe that real innovation probably doesn't stand very much of a chance of being seriously considered, and that the guy who comes in with something really innovative may, in fact, be the guy shoved out the door.

Mr. STOFAN. In our RFPs we have a specific request in the RFPs for the contractor with any innovative ideas, and I expect the contractors to come back to us with innovative ideas on the Space Station.

Mr. WALKER. But I bet you they will be innovative ideas based around the design parameters that they think that you have locked yourselves into, and that the bottom line is that they will, in fact, bring you innovative ideas within the modules, they will, in fact, bring you innovative ideas to be used out of the choices, but no one will come to you and suggest, hey, let's take all of the power off the station and put it in a satellite somewhere out there and say to private industry, you build that satellite for us.

I bet you that no one will come in with that proposal because there is no economic incentive to do so. All the economic incentives are aimed at getting the NASA contracts, and as long as all the economic incentives are to get NASA contracts, they will do exactly what they think NASA wants. That is, I think, a real concern at the present time, and it seems to me it may be drying up resources that might otherwise be there.

Mr. NELSON. Would the gentleman yield?

Mr. WALKER. I would be glad to yield to the chairman.

Mr. NELSON. I would like to explore—let me preface my question with a comment. Indeed, his RFP process is the design process, and the respondents to the RFP process have to respond to that. So that is where you get a lot of the lock step conformity that you are concerned about. It is built into the process. But let's take, for example, a deviation from that. Did you ever consider, instead of you building a co-orbiting platform, that you would have private industry build a co-orbiting platform?

Mr. STOFAN. In fact, Max Faget is a man-tended free flier. He is going to build one of those.

Mr. NELSON. Well, is that part of your Space Station RFP?

Mr. STOFAN. No, not Max's. He is proposing to us that he is going to go out and develop it and he is going to have it commercial and he wants to make it compatible with the Station. The country will end up with a bigger capability, and part of it will be commercial, and yes, in that instance it is exactly what we are doing. If someone wanted to come in, say a commercial company, and wanted to build a co-orbiting platform, great, we would love to see it come in. That is super.

We are encouraging this all over to do it. We haven't gone out and paid someone money to come in and tell us ideas. I guess all the great innovative ideas that are out there that are going to save us all this money that NASA is suppressing all around, that is just the figment of somebody's imagination. All these great things aren't out there. We will go with any innovative idea anybody has, and we encourage it every single chance we get. We are not forcing the contractors to do something that is not economical. We would love innovative ideas on the Station.

Mr. NELSON. Does your mission for a co-orbiting platform have a significantly different mission than a Max Faget type mission?

Mr. STOFAN. Yes, totally different. The co-orbiting platform presently is one that will do space sciences, and in the initial co-orbiting platform, the instrument is not developed by the Space Station people, it is developed out of the science community. That initial one is called AXF, which is an x-ray telescope that is being developed to go on a co-orbiting platform. If it turns out it isn't, another one under consideration—the infrared telescope, that would go onto a platform. There are scientific instruments on both the polar and the co-orbiting platform and it is to do science.

Again, if some company came in and said they wanted to put that up and they would sell AXF data back to the science users or the country or whomever, fine. We have absolutely no objection to that type of proposal coming back.

Mr. NELSON. Would they be, because of the sensitivity of the science instruments, prohibited from being on such a platform as a commercial-type platform?

Mr. STOFAN. Not if the commercial platform met the requirements of the scientific instrument, no.

Mr. MARTION. Let me, Mr. Chairman——

Mr. NELSON. I want you to answer that one specifically, and then we will get into whatever you want to talk about, but answer that specifically.

Mr. STOFAN. That there is no reason why a company could not build a platform that was totally compatible with the science instrument.

Mr. NELSON. Is that within the scope of the MOU that you have signed with Dr. Faget?

Mr. STOFAN. No. What we are working with, we are working on a memorandum. We have not signed it. What we are working with him is an agreement that we will work with him such that his man-tended free flier is compatible with the station and can be serviced by the station if he would want it to be. At this time his

plans are to use that as a Shuttle compatible because he wants to launch it in the nineties. He just wants to make sure that in the later years it is not only Shuttle compatible but it is station compatible. So we are working with him so it can be station compatible so that if he wants to some time in the future have the Station service it and work out an agreement with us, that we are able to do that.

Mr. MOSER. His facility is basically a microgravity processing facility as opposed to an XF or a——

Mr. NELSON. I understand, but you are saying that there is nothing that would prohibit the mixing of the two.

Mr. MARTION. Yes, that was my point, Mr. Chairman. Because of the frequent changes in pointing that you use in astronomy and some of your Earth observation requirements, that causes you to disturb the environment that you can do your materials processing in. So the Max Faget facility is ideally suited for extended periods of time and low gravity, but if you are going to be moving around to different targets in the sky, you are going to disturb that.

So those two requirements are fundamentally incompatible. Now, that doesn't mean you couldn't go and obtain a commercial vehicle, obtain some sort of lease craft, which I think CODE has looked at in the past for doing some of their requirements, but I would not want to see those together.

Mr. NELSON. What you are telling me, then, is some of the experiments that could be, that you were planning to be on a co-orbiting platform that could go on a kind of commercial facility, and in addition there are others that it would be highly desirable that they not be on a commercial facility, but that if you didn't have any funds for a co-orbiting platform, you could explore the idea of a leasecraft. Is that what you are telling us?

Mr. MARTION. You could do that, but I think you should talk to the folks in Bert Edelson's organization about that because sooner or later the government winds up paying for that lease if it is for scientific purposes. If it is for a commercial purpose, then you have other sources of funds.

Mr. STOFAN. And that really is the CODE's responsibility to carry that out.

Mr. NELSON. Mr. Walker.

Mr. WALKER. But we lease facilities all the time for the Federal Government. What I hear you saying is it wouldn't be a good idea to put science instruments aboard a Max Faget module that was out there doing materials research, but why hasn't somebody been negotiating with Max Faget about the co-orbiting platform that we need for the station for our scientific purposes? Why not buy that from the commercial sector? Why not encourage the commercial sector rather than looking to build that ourselves?

Mr. STOFAN. That is not the responsibility. Scientific instruments are not my responsibility. That is CODE, and I think you should ask them that question.

Mr. WALKER. But again, within your agency, as long as they think you are building the facility, they are not about to go out to Max Faget or anybody and talk to him about it. It is a part of your design.

Mr. STOFAN. Let's take specifically the scientific instrument. The customers for the science data are the university professors and the NASA people. Now, are they going to pay a commercial venture so many dollars per bit? The science program, especially the astrophysics and space science program, the only space science program is the one that is funded by the U.S. Government. There is no other need for the data. That data is not like a LANDSAT where it has use. Its use is for a few astrophysicists, most of them in universities, and if they had money, you know where they would get the money to pay for it? They would get the money from NASA to pay for that data.

So it's kind of—not the science program. If you have a commercial program or a commercial potential, then I can see it, but I don't quite see how this applies to the pure science program.

Mr. WALKER. What I am suggesting to you is that the government for many, many different things leases space, leases instrumentation, whatever it might be, from the commercial sector. Over the long haul of the budget constraints that we have here, such a leasing program might, in fact, even though it is more costly over a long period of time, may fit more with the budget constraints that we have as a government than some other program, plus we get all of the additional investment as a society that will go with the private money having been invested in this in the first place.

Mr. STOFAN. Didn't you do something like that on TDRESS?

Mr. WALKER. We may have. I don't know. But all I am suggesting is I don't see very much encouragement of the commercial sector to get involved here and put their resources in. As long as there is the belief that the only way we are going to get into space and the only way we are going to have a station is with NASA contracting, we aren't going to get it, either.

Thank you, Mr. Chairman.

Mr. NELSON. The long and short of it is that everybody is frustrated. We are frustrated, you are frustrated, this thing has dragged on far too long, and this very conversation is being carried on in the context that the Budget Committee right now is trying to decide between a $1.8 billion cut and a $1.4 billion cut in the President's request.

Now, if that occurs, you can kiss the whole Space Station goodbye.

Mr. STOFAN. And maybe all of NASA, too, the future of the agency.

Mr. NELSON. But that is not going to occur——

Mr. STOFAN. I hope not.

Mr. NELSON [continuing]. Because there is enough resident support out there in the country that if we have to kill a budget resolution on the Floor, I think we can if it comes forth out of the committee with that kind of cut. But nevertheless, that is the realities that we are having to face today.

Let's just wind up. You-all have been very helpful. What I wanted to do today was float this idea, put it up as a trial balloon, and also what I wanted to do was to get you guys thinking about the realities that we have to deal with because we are the ones that have to fund the money for you, and that increasingly is not an easy job.

When you are in a position to report back to the committee, would you please give us the design and the schedule that could be accomplished under——

Mr. STOFAN. As soon as possible.

Mr. NELSON [continuing]. Under this kind of proposal.

Mr. STOFAN. Yes.

Mr. NELSON. Thank you, gentlemen. Have a nice day. Keep your chin up.

Let's have Dr. Andelin and Dr. Williamson.

Dr. Andelin, I guess the way to approach the situation here, let me just ask you a series of questions and other members are encouraged to jump in here at any time. This was produced by the Science, Information and Natural Resources Division of the Office of Technology Assessment, Civilian Space Stations and the U.S. Future in Space, so you all in the Office of Technology Assessment have indeed a reservoir of information that we want to draw on.

Over the course of three hours now you definitely know where we are coming from and where we are going to and what are the frustrations that are facing all of us.

So let me just ask you, how flexible are the technologies NASA is investigating and how much of the Phase B work might be applicable to some new configuration or assembly kind of different design?

**STATEMENT OF DR. JOHN P. ANDELIN, ASSISTANT DIRECTOR, SCIENCE, INFORMATION AND NATURAL RESOURCES DIVISION, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY DR. RAY WILLIAMSON, SENIOR ANALYST, INTERNATIONAL SECURITY AND COMMERCE DIVISION, OFFICE OF TECHNOLOGY ASSESSMENT**

Dr. ANDELIN. Thank you, Mr. Chairman. The NASA design and the Phase B studies were largely directed towards the NASA space station that you heard about for the last few hours. There are within that space station considerable numbers of generic items. There are life support systems, docking systems, hatitable structure systems, power generation systems for which the specific designs would not necessarily be applicable nor the specific cost estimates, but clearly, these are largely transferable.

There are other aspects of the design that clearly would not be transferable to a proposal such as that that you have raised this afternoon.

Some elements that have come out in that process that are both transferable and not are ways of estimating costs that led in the case of NASA's previous space station proposal to change, along with some design changes, the cost estimate from eight to $15 or $20 billion dollars.

Those techniques for estimating costs are clearly also transferable.

Dr. WILLIAMSON. Well, I would just like to add to that that NASA has attempted to design certain portions of their space station infrastructure as modules so that those kinds of modules can be transferred as well.

The idea is that as the station grows larger, you add more of the modules. By the same token, you can take those modules and transfer them to a different design.

In addition to the portion of the space station that we normally think about, we also have a polar platform which Dr. Stofan mentioned a couple of times in passing and much of the work has been done or is being done now for the polar platform can be transferred.

So there are a number of elements that can move over to a different configuration for the overall space station.

Mr. NELSON. All right. So to summarize what you said then, what you said is that the Phase B design work and planning work that they have done doesn't lock us into a particular configuration and the Phase B work if you shifted to a different configuration is not wasted?

Dr. WILLIAMSON. Yes, that is correct.

Mr. NELSON. All right. What would be the benefits and the drawbacks of imposing a funding envelope of the type that we have thrown out on the table here today?

Dr. ANDELIN. Let me make a few comments that are effectively from my prepared testimony. There are some clear advantages to a level funding option. There are also some disadvantages.

The predictability and the stability that that would bring to the program would obviously ease some of the political problems. It would allow NASA itself and the contractors to better judge the staffing needs, the procurement needs, that would otherwise come on the year-by-year vagaries of the budget process.

There would be some advantage in that, by fixing the cost and asking them to design to the cost, there would be less tendency for what one might call unrealistic deadlines, and there would be less pressure to try to meet those by affecting other programs or by rushing through something.

There would clearly be encouragement to NASA to seek private contributions, because you are saying, in effect, "you may not have what you wish to have, and, as a result, if you want the station that we, the committee, would like to see, we would help you work out ways to work with private industry to enhance that that the government can directly fund."

I suspect there would be, in the later stages of the NASA activity, some incentive to keep down operational costs, and that would in turn reflect back in the early design stages to ask them to look at automation and robotics differently than they now might be doing. The operational costs that are suggested in the press release are lower than the usual rules of thumb for major construction projects. They may well be appropriate, but they are somewhat lower than we would have guessed on just the rules of thumb.

So to some extent if NASA believes they can do something for that, the burden of proof is on them to show it. But that would encourage them to look at ways to keep operational costs down. That would be in some sense opening a wedge ten years out for some next activity or for enhancing the space infrastructure then in place, the thing they call a space station.

So I don't know whether it is an advantage or a disadvantage but it clearly puts NASA in a more limited, a little more certain

budget situation, and encourages them to look for ways to haul the budget down—cost sharing, international negotiations, private partners and less expense on some of the activities, with extra regard to, maybe, automation.

One could imagine the stability of that could take on some aspects of, I wouldn't say a treaty, but it is an agreement between the Congress and NASA that there will be this continued support, that it isn't what anybody might have hoped for in the first place but it is what will work. And that implies again greater continuity than the annual budget cycle usually does.

One could imagine that, with some initial difficulties, our western European and Japanese allies could be encouraged by the stability. There are, after all, some historical examples where we have not been a perfect cooperative partner in space or other high technology programs. We have changed our mind for one reason or another.

Finally, one could imagine that this would give Congress an opportunity to enter into a continuing dialogue with NASA—to review where they are, where they are going, what the costs are—to see more carefully the need for the escape vehicle or escape hatch, extra funding to discuss the use of additional transportation, whether it is the heavy lift vehicle or various local or more distant orbital vehicles. You could see what is coming in and what is not, and have a chance to discuss it as it goes.

So we see numerous advantages to it.

There are some problems, clearly, It is true historically that most major projects have a lower initial funding, peak in the middle and then fall off. Forcing that into a different shape will perhaps have some costs. How much those costs are will probably depend upon the level.

That is, the advantages I listed are not level dependent. Whatever number you pick, those same advantages that accrue from stability are true.

The costs will depend upon that level, so the lower the level the greater the costs, the greater the dislocations, the more the delay, the more the diminution in eventual capabilities of the space infrastructure that is put up.

I suspect that some of the problems with the shape of the curve could be handled with some no year funding arguments, but if they wish to stockpile a bit for future years to build up, and if appropriations and the budget committees agree with that, those things have worked in the past for construction projects.

Mr. NELSON. Let me interrupt you. Mr. Walker.

Mr. WALKER. All right. Just a couple of questions. How much consulting has NASA done with you on your concept as I understand it came out a couple of years ago on the concept of space infrastructure?

Dr. WILLIAMSON. Well, we certainly, when the study was in progress, consulted with NASA quite a bit.

Mr. WALKER. No, how much have they come to you and asked you about how your ideas on this and how to implement it?

Dr. WILLIAMSON. Well, I haven't talked with them at all about this and you have to understand that I was not specifically part of this project, although I had input to it. I was doing another project.

Dr. ANDELIN. The answer is certainly very little

Mr. WALKER. I am sorry. I am interrupting here because we have to run for a vote. In other words, this is not something that NASA has pursued.

Dr. WILLIAMSON. No.

Mr. WALKER. Have you seen any evidence that they have been pursuing it on their own?

Dr. WILLIAMSON. No.

Mr. WALKER. No. It is very interesting. I wonder if there is anybody in the room from NASA, can you raise your hand?

[No response.]

Mr. WALKER. Not a soul. Now as soon as they are finished and so on and they have given us their technical version of reality and so on, they all pick up and walk out of the room and this is exactly the kind of technical arrogance that we have run into on this program time and time again and if it wasn't invented in NASA, it is not worth listening to and in all honesty, I find much of what you have here being very valuable because it is a way of involving a lot of people into this business of funding how we get to space that go beyond the NASA funding stream.

What you are saying to us is very, very valuable and I am sorry our time is cut short by the vote. But let me ask you this. Are you free within the next probably say sometime next week to come into my office and talk to me a little bit.

Dr. ANDELIN. Of course.

Dr. WILLIAMSON. Yes, indeed, certainly.

Mr. WALKER. I want to go over this in some detail.

Dr. WILLIAMSON. I would be glad to.

Mr. WALKER. Thank you very much.

Dr. ANDELIN. We would be pleased to brief individual members, the subcommittee as a whole, or respond to questions in writing.

Mr. WALKER. Thank you very much.

Mr. NELSON. We will go vote. There are two votes, at least two suspensions and then we will come back.

Mr. NAGLE. Mr. Chairman, I want to make it easy for you if I can. I don't have any questions. Maybe the Chairman has further questions.

Mr. NELSON. I do. I have a number of questions.

Mr. NAGLE. I tried, gentlemen. I tried. [Laughter.]

Mr. NELSON. Good, true.

Dr. ANDELIN. We have worked for Congress for quite a while. Take your time, we will be here.

Mr. NELSON. We will recess.

[Recess.]

Mr. NELSON. Okay. Let's resume.

How about if you all will just address questions and just address them right to the point.

What role would this proposal that we have thrown on the table for a space station affect U.S. competitiveness and a potential mission to Mars?

Dr. ANDELIN. Let me ask Dr. Williamson to answer that one.

Mr. NELSON. Dr. Williamson?

Dr. WILLIAMSON. Well, I think we have to separate two things. First of all, let me just separate the competitiveness aspect, which I

understand to be economic competitiveness, versus the kind of political competitiveness, that we might have, say with the Soviet Union. In terms of our economic competitiveness, we see it potentially improving our competitiveness in the sense that by asking NASA to go and be perhaps more innovative in the design, work with the private sector more and so forth, that would help our competitiveness in that area.

The concern that we would have overall for funding for a large project which might not fit within cost goals is that it might crowd out other aspects of our space program; there's where some really good payoffs are coming today in our competitiveness with the rest of the world. Things like satellite communications. The United States is clearly number one in communication satellites, for instance, right now, although we face competition from our European allies and from the Japanese specifically in that area.

So, another example is the LANDSAT program. Somehow we haven't been able to get a really good way to keep the LANDSAT program going and the French are competing with the SPOT satellite and the Japanese have just put up a marine observation satellite.

So, from the standpoint of that kind of economic competitiveness, a funding envelope and a cost, design to cost could help us a lot, we think, in that area.

The other question that you asked, which is part of that same question, the potential mission to Mars, we have the concern that if there isn't a funding wedge developing in the latter part of the 1990's, then it may be very difficult to mount that mission to Mars, whether it's a mannned mission or an unmanned mission, to collect samples and so forth.

So, on that score, the question is can NASA bring that funding envelope down to create the wedge that would allow that program and other potential programs.

Mr. NELSON. When you did the 1984 study, what assumptions did you make concerning the growth in the funding wedge that would be available to the station?

Dr. ANDELIN. In 1984, the budget was approximately $7 billion, of which $2 billion had to do with the shuttle development. We were told pretty much by NASA and the general wisdom, that $2 billion would soon be unneeded and that the base NASA budget of approximately $5 billion would therefore have room above it—if we stayed at roughly $7 billion—of a couple billion dollars a year. We also assumed, in trying to understand what one might have as space infrastructure over the next 10 to 25 years, that there would be some actual growth in the NASA budget in real terms. We assumed approximately 1 percent per year as realistic and presently agreed to.

Finally, we looked to see what kind of contribution one might expect from the private sector or international partners, and we did not pick numbers for that with any care, only that there could be certainly over 25 years a substantial contribution.

Over 25 years, a long period of time, that turned out to be $50 billion for the $2 billion wedge, (the $2 billion decline of the shuttle cost) $25 billion came from this 1 percent real growth and some tens of billions perhaps by private sector or partners.

So we were saying that over 25 years, if the wedge was there and there was 1 percent growth and some cooperation, there would be $75 to $100 billion available. By any estimates, that bought everything that was for sale or imagined in those days. Some of our tables reflect that, had that been begun in the 1984 timeframe with that kind of planning, and had the wedge developed, by 2000 we would have a space station considerably larger than NASA had imagined; by 2010, we would be well on our way to asteroids, to the Moon, Mars, something of that nature—truly, some of the more glamorous missions.

Over 10 or 15 years, those numbers are correspondingly smaller, but over 10 years, that is through 1995, 1994/1995, it comes to something between $20 and $30 billion, which was again much larger than the space station costs and those of many other pieces that one might add, additional polar orbiters and staging grounds and so on.

What occurred, of course, was that that didn't occur, and what we see today is that the NASA base budget is not the roughly $5 billion that we were talking about, $7 minus $2, but it seems to be closer to the $8 billion they have already. So that instead of a $2 billion wedge, there appeared for a number of reasons—among them clearly being the Challenger, not counting replacement costs—instead of a $2 billion wedge, there's more like a $1 billion addition in that 3 to 4 years. That's of course particularly disappointing to plans to fit some of the space infrastructure into the existing envelope.

We fully expected to be able to build the space station then proposed by NASA, should the Congress choose to do so, by the mid to late 1990's within that kind of a wedge; so that the—what should I say—the political response has been very disappointing to those of us would like to see things done in space that lead to better competition and better science.

As a matter of fact, as we now (with rather quick updates of our work) seem to be told, there isn't a wedge in the foreseeable future, I mean in the next several years. There's no wedge appearing out of the $8 billion either, that is really what is needed for ongoing activities, not including the shuttle, some of the transportation vehicles from here up or from up there around. It's a bleak budget picture today.

Mr. NELSON. Where did that wedge go when the budget went from $7 billion to $10 billion? Let's say $9.5 billion, which is what the President's request is, assuming that we get that, where did that wedge go, since you did have an increase which, I haven't calculated it, but that's not too far off from a 1 percent real growth per year.

Dr. ANDELIN. According to the CBO staff paper, I believe they have seen a 3 percent real growth for the last five years, from 1982 to 1987.

Mr. NELSON. I'm talking about from your study, since 1984. Okay, so the factor of 1 percent real growth is still there, so where did the wedge go?

Dr. ANDELIN. Oh, it's much more—I mean from $7 billion to more like $9 billion.

Mr. NELSON. $7 to $9.5 billion.

Dr. ANDELIN. I mean, that's a 40 percent increase in actual in four years. That's more like an 8 percent annual growth. (I don't know how inflation affects this).

Mr. NELSON. What I'm trying to get at, what happened to the wedge?

Dr. ANDELIN. Clearly, the loss of the Challenger has affected all of their operations. There are increased costs in space science because things instead of being up there, being used, are here, warehoused, and that costs money. There are continuing shuttle development costs as large as they were before.

Mr. NELSON. And the loss of revenue.

Dr. ANDELIN. There's clearly quarter of a billion, $400 million loss of revenue. The wedge is gone. As I say, we have not now been told there is any significant hope of some decrease in the base budget for several years to come. So instead of it being $5 billion, you are talking about, plus new starts, it's $8 to $9 billion plus new starts. As I say, it's a bleak budget picture.

Dr. WILLIAMSON. I think one of the points to bring out clearly is that the Challenger accident and the recovery—and I don't mean replacing the orbiter but all of the peripheral things—has had an effect on every aspect, or nearly every aspect, of the NASA budget, and that certainly has played a role over the last couple of years.

Another thing that seems to have played a role, and I'd have to look at the numbers more carefully to be absolutely sure of this, but the operations cost for the shuttle have been a lot higher than had been expected and that certainly accounts for part of the wedge.

Mr. NELSON. Dr. Andelin, what did you say, about 8 to 9? I didn't understand, the last thing you said was something 8 to 9. What was that?

Dr. ANDELIN. I guess I was saying I didn't take inflation into account, but the growth in the NASA budget in current dollars has been more like 8 or 9 percent a year. I assume the inflation from 1984 to now probably runs 4, so that's 4 percent real growth in the last four years. Again, looking in the CBO report, it shows from 1986 to 1987, for example, the pre-accident costs for space flight, control and data communications went from $3.2 billion before the accident in 1986 to $5.8 billion after the accident in 1987. There's a $2.6 billion increase having to do with that accident. I don't have the details that CBO has, but it's clear that the cost of the Challenger was not the cost to buy another shuttle. The cost of the Challenger is probably measured in a few tens of billions over the past year and the next four, maybe more than that, because now there is a two year break in flights, because of safety considerations. They won't fly the 20–25 a year but probably more like 10 or 15 when they are back in business.

That means all other things get postponed, so science experiments are being postponed. I've seen 5, 6, 7, 8 years, and others not even rescheduled. That costs money to keep people on idle that gives nothing in return; very costly.

Mr. NELSON. Let's talk about the operational costs. You know, this thing we threw out on the table today says okay, after you develop the station, then we are talking about limiting the operation costs to $700 million a year. What do you think about that?

Dr. ANDELIN. I must say we have no experience in budgetary matters at that level. We have a couple of programs at OTA that have looked for their own interests, not at space costs. We have looked some at military costs and we have looked some at the costs of traditional science facilities, research facilities.

The rule of thumb, but it's different from facility to facility, is 15 percent of the capital cost is a fair estimate of annual operating and maintenance costs, plus or minus about 5 percent.

So 10 to 15, maybe 20 percent. That means if it is a $15 billion space station (some of those costs aren't real capital costs, they are the transportation up and some other things) you would expect more like $1.5 billion or $2 billion than $700 million.

I have been told that a number that is relevant, but I don't have it with me today, is to look at the projected operating costs of the Hubble space telescope and see what that looks like, and see (given that complexity) how one might extrapolate that to space station.

It may be a very good number, sir, but it surprised those of us that looked at other programs because it appeared small.

Dr. WILLIAMSON. I think one of the points we also wanted to bring out with respect to operational costs is that whether it is $700 million or $1.5 billion dollars per year, that those costs should be understood well. The other set of costs which one might want to look at, what people have called the utilization costs, namely after you get the structure up and you have it operating, are the costs to actually do some experiments there.

Those generally go into other budgets, and sort of properly so because it costs the space science budget and the applications budget and so forth. But nonetheless, one might want to ask whether it's more expensive or less expensive or what are the tradeoffs for doing work on the space station that might be done someplace else, that whole set of questions. It may be that NASA has studies on that, but I'm not aware of them though.

Mr. NELSON. What do we need to do in your opinion in a meaningful technology development program in materials processing and life sciences on the space station when it becomes operational?

Dr. ANDELIN. We asked that question with some care back in 1983/1984 when we were doing the study, and I'm not sure we received an answer that told us the technical community knew what they would do with a space station with regard to those areas. Similarly, we checked a bit with the commercial sector and found if one said, given the space station, could you use it for something, most said yes; if we said, given an opportunity to rent space on a space station and pay some fraction of costs, how much would you be willing to spend for that opportunity, the answer generally was well, usually the Feds pay for all that, don't they, and there was very much reduced interest if they had to pay for it themselves.

Mr. NELSON. That was in 1984?

Dr. ANDELIN. Yes, sir.

Mr. NELSON. You would concede that in 1987, it's a considerably different situation?

Dr. ANDELIN. I don't know. I would hope it is. We have not updated it.

Mr. NELSON. I can tell you that, yes, it is. It's a different situation.

Dr. WILLIAMSON. I think if I may add to that, one of the plans that was going forward before the shuttle disaster was to use the shuttle for a lot of experiments in materials processing. There are some very interesting things, but we haven't done the science yet and we still haven't been able to do the science, because of not having the flight opportunities on the shuttle. So, there is some concern that in designing the materials processing part or the materials science part of the space station, that we right today may be a little premature until we have more information about that.

Frankly, the question—the way we might put it is, what kind of program can we put in place to enhance space station planning, once you have your basic capacity, or planning for your basic capacity. What are the kinds of things that we need to do between now and 1992 or 1993, or whenever one needs to make final decisions about some of the items that actually go into the laboratory? There needs to be a well designed program for that.

I know NASA is working on those issues but I wanted to underscore the need for the basic research to give us some answers back.

Mr. NELSON. All right. Does staff have any questions?

[No response.]

Mr. NELSON. Gentlemen, thank you. It's been a long day. Have a good evening.

[The prepared statement plus answers to questions asked of Dr. Andelin follow:]

**STATEMENT OF JOHN P. ANDELIN**
Assistant Director
Science, Information, and Natural Resources Division
Accompanied by Ray Williamson
Senior Analyst
Office of Technology Assessment

Testimony Before

The Subcommittee on Space Science and Applications
The Committee on Science, Space, and Technology
United States Senate

# CIVILIAN SPACE STATIONS AND THE U.S. FUTURE IN SPACE

March 31, 1987

## STATEMENT OF JOHN P. ANDELIN

Mr. Chairman and Members of the Subcommittee:

I am John Andelin, Assistant Director of the Office of Technology Assessment. With me this afternoon at the witness table is Dr. Ray Williamson, Senior Analyst.

A little over two years ago, OTA delivered to Congress an assessment of the proposed civilian space station. In our analysis, requested by the Committee on Science and Technology and by the Committee on Commerce, Science, and Transportation of the Senate, we placed particular attention on the relationship between the objectives of the space station and its design and development; on issues of cost and efficiency; and on the relationship of the space station to the entire civilian space program. Indeed, this Committee was particularly forceful in asking that OTA review the need for a space station as well as alternative approaches.

Things have changed since we delivered our report. The NASA definition work has recently provided updated cost estimates for the space station — estimates that are considerably higher than they were. The Challenger loss has caused delays in scheduling and in the development of information important to understanding space station operation and utility. Despite these and other changes, however, we find that much of our analysis is still valuable to today's discussion; the questions addressed by OTA in 1984 are still the critical issues facing the Congress as it seeks to determine the proper path for the development of space.

In fact, much of the language of the debate of two years ago continues to be current. At that time, NASA was contending that "The Space Station " was the best, or perhaps only, choice; that funding and acquisition must be done in the traditional manner; and that no precise definition of the purpose and uses of the facility was necessary. The space station was defined as the generic "next logical step in space," and few objections or questions were encouraged by NASA.

After thorough analysis by OTA, with the review and support of a distinguished Advisory Panel (list of members is attached) and many other experts, OTA came to a conclusion that we believe remains true today. That conclusion, in a nutshell, is that there is a persuasive case for the continued development of space and for the acquisition of some long-term, inhabitable infrastructure in low-Earth-orbit — but no such case has been made that a particular configuration on a specific timetable is the only way — or even necessarily the best way — to reach the promise of that development. We see the proposal for a space station as an opportunity to develop a clear understanding of specific, national goals, following which the infrastructure to meet those goals can be effectively developed and deployed along any of several paths of time and money.

A brief glance at some of the principal Tables prepared for our study will indicate to the Committee that a wide variety of approaches, with a wide variety of costs, can be defined to meet a number of goals and objectives. (Tables are attached at the back of the testimony.) It is important to note that the costs shown in these tables were derived from similar engineering data and in the same time frame as was NASA's estimate of $8 billion for their proposed space station. Given the considerable upward revision that has taken place in NASA's estimate, it would seem prudent to correspondingly increase OTA's estimates.

OTA devoted a substantial fraction of the project's resources to producing these documents, largely in response to this Committee's interest in alternatives. As you can see, the Tables indicate that choices are possible. Space infrastructure can be made up with various combinations of characteristics to meet different needs. What is important from the standpoint of funding decisions on the space station program is that there be a crystal clear understanding of the actual objectives to be served by the resulting space infrastructures, and that the configuration selected is capable of meeting those needs in the most cost-effective way.

Let's see what this means in practice. Any space infrastructure, even one characterized as generic or all-purpose, has specific characteristics such as orbit, on-orbit lifetime, volume, stability, thermal control, safety, power, communications, local transportation, storage capacity and human accommodations. When OTA completed its analysis, considering the space technology available and expected to be available shortly, we concluded that a facility defined as a space station could vary from a small passive platform, then estimated to cost as little as $5 million, to a much more sophisticated, essentially permanent facility that could support a large human crew and a wide range of activities. The number of personnel to be accommodated could range from 0-10, the pressurized volume from 0-10,000 cubic feet, the power available to users up to 200 kilowatts, and so on.

Since our report was published, NASA has spent additional time and money to develop a preferred configuration for its proposed space station. It would seem useful for the Congress to understand, from NASA, what alternative choices have been rejected, for what reasons, and specifically how the space station it proposes might serve several possible goals and objectives — those identified by OTA or others.



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For example, OTA developed a set of infrastructure elements that would allow most of the life science, materials science, and plasma physics experiments to be conducted that had been identified by the scientific community as important (in 1984). While we did not conduct a detailed engineering study, OTA concluded that by making good use of already developed technology, keeping technology modifications to a minimum, employing modern, cost-conscious, commercial-like acquisition practices, and cost-sharing with other countries, the operational capabilities to meet scientific requirements and to allow low-Earth-orbit satellite-servicing could be obtained for a total cost then estimated to be considerably less than NASA's proposal for a space station, and placed in orbit in about five years. The analysis also showed that the capability of such a facility would be substantially greater than that provided by the Soviet Union's Salyut 7 infrastructure. (For purposes of comparison, we note that the European Space Agency plans to acquire three major infrastructure elements within a cost envelope of $3-4 billion.)

The fact that OTA was able to define a useful configuration of space infrastructure for substantially less than NASA's proposed space station, and that this suggested configuration passed muster by reviewers of our study, strongly suggests that significant achievements in space can be accomplished over a wide range of funding levels. This does not suggest that we can get more than we pay for. If Congress wishes all the capabilities of the NASA space station and wants it by 1994, there may be little choice in funding. But if different capabilities are either acceptable or preferred, or if the deadline can be slipped, other funding options are possible.

What then does all of this mean for the questions now before the Committee? OTA's analysis showed that a wide variety of space infrastructures is possible, and NASA has chosen one of them. In broad terms, we believe that the NASA space station design is well-adapted to serve two purposes: 1) to establish a permanent manned presence in

space beginning in 1994, or anyway the mid 1990s; and 2) to provide a base from which incremental improvements can be made so that we will have a useful and versatile orbital infrastructure as we move into the next century. Accomplishing both of these goals at once may cost at least much as NASA says it will.

Mr. Chairman, this suggests four major options which this Committee, and the Nation, ought to consider:

Option 1: Fund the NASA proposal as NASA requests. This would be a responsible course of action only if the overall NASA budget can rise substantially over the next few years. Given the present level of the Federal deficit, this may not be an easy course to take.

Option 2: Select and fund as needed Congressionally defined assets and services and a date by which they should become available. If a clear concensus on goals of our civilian space program had been reached, funding either the NASA space station (assuming that it met those goals) or specifying other assets and services and paying whatever the cost would seem responsible. In the absence of such clear goals, and especially in the face of the pressures upon Congress to hold down Federal expenditures, this may not create an effective and efficient space program.

The next two options relate to the concept of sustained funding over time. That is, the Congress could consider providing a fixed amount of resources for an extended period of time, as opposed to the more characteristic funding of NASA projects — a rapid increase in funding, a brief plateau, and then a fall-off. There seem to be several reasons for relatively level funding. First, such funding provides a level of predictability and stability often lacking in government projects. Such stability generally makes for

efficient management and procurement. Second, in a situation in which there is no requirement for spectacular results to justify high funding, NASA would not be pushed to provide results on unrealistic timetables. Third, a steady future of exciting civilian space work would allow NASA and contractors to attract and hold good people. Fourth, level and predictable funding might facilitate cooperation with western Europe and Japan, giving us all more capability within the individual national funding constraints. Finally, given such a funding pattern, NASA and the Congress could enter into a continuing dialogue over changing priorities and options. As objectives and technology changed, adjustments could be made to the facility on the basis of need.

Option 3: Establish a funding profile with an annual ceiling for the space station expenditures of $1-2 billion, and ask NASA to redesign the space station to stay within this boundary while still aiming to establish a space station in the mid 1990s. There are two major drawbacks to this course: first, while such a redesigned, cheaper station is perfectly possible, it would certainly lack some of the capabilities of the current design; second, and most important, the redesign may have to be quite radical if the growth potential of the current NASA design is to be preserved. This would probably mean redoing a significant amount of the detailed design and definition work that has been put into the current design before we could be clear on how great the sacrifice of capabilities would be.

Option 4: Establish a funding profile with an annual ceiling for space station expenditures of $1-2 billion, but retain the major features of the existing design. This would mean stretching out the schedule, so that it would be several years later — perhaps the late 1990s — before the space station would be fully operational and inhabited. However, if we can be patient and settle for less capability in the near term, this option would give us the full growth potential of the existing design after the turn of the

century, and establish a pattern of steady progress towards our objectives. As our report emphasized very strongly, a space infrastructure that is useful is never complete — we will always be discovering new possibilities that require growth of the space infrastructure. Therefore it is a mistake to think in terms of "the" cost of "the" space station — the right way to approach it is the "level of effort" on "space infrastructure" whose eventual scope we can only dimly foresee.

In summary, OTA suggests that the Subcommittee utilize the existing OTA analysis as a framework for requesting that NASA provide updated information on alternative configurations, objectives and purposes for the space station. This could include alternative levels of participation by our foreign partners, some of whom have expressed concern that their role is being unduly circumscribed. A submission to the Committee by NASA could then be reviewed by knowledgable people outside the agency. This would expand the options before the Congress, and assist the Subcommittee in its endeavor to balance the immediate desire of the requesting agency, the costs of development, and the long-term goals of the civilian space program.

**Table 1.—Comparison of Some Options[a] for Low-Earth-Orbit Independently Operating Infrastructure**

| | Shuttle Orbiter | Extended Duration Orbiter: Phase I | Extended Duration Orbiter: Phase II | Free-flying spacelab (developed as permanent infrastructure) | NASA infrastructure aspirations: Initial operational capability | NASA infrastructure aspirations: Mature, fully developed |
|---|---|---|---|---|---|---|
| Date available (assuming start in 1985) | Now | 1988 | 1990 | 1990 | 1992 | 1998–2000 |
| Cost[b] (billions of fiscal year 1984 dollars) | None | 0.2 | 0.5 | 2–3 | 8 | 20 |
| Characteristics | | | | | | |
| Power to users (kW) | 7 | 7 | 20 | 6 | 80 | 200 |
| Pressurized volume ($m^3$) | 60 | 60 | 100 (with Spacelab habitat) | 100 | 200 | 300 |
| Nominal crew size | 6 | 5 | 5 | 3 | 8 | 20 |
| Miscellaneous | Can accept Spacelab | No new technology | New technology required; modest laboratory space | Modest crew accommodations | Orbital maneuvering vehicle plus two free-flying unpressurized platforms | Reusable orbital transfer vehicle plus several more platforms |
| Capabilities[c] | | | | | | |
| Time on Orbit | 10 days | 20 days | 50 days | Unlimited (60–90 day resupply) | Unlimited (90 day resupply) | Unlimited (90 day resupply) |
| Laboratories for: | | | | | | |
| Life sciences | Moderate | Moderate | Considerable | Extensive | Extensive | Extensive |
| Space science/applications | Modest | Modest | Modest | Modest | Extensive | Extensive |
| Materials science | Some | Some | Moderate | Moderate | Extensive | Extensive |
| Technology development | Modest | Modest | Some | Moderate | Extensive | Extensive |
| Observatories | No | Modest | Modest | Modest | Extensive | Extensive |
| Data/communication node | No | No | No | No | Considerable | Extensive |
| Servicing of satellites | Modest | Modest | Modest | Modest | Considerable | Extensive |
| Manufacturing facility (materials processing) | No | No | Modest | Modest | Considerable | Extensive |
| Large structure assembly | No | No | No | Modest | Moderate | Extensive |
| Transportation node | No | No | No | No | Moderate | Extensive[d] |
| Fuel and supply depot | No | No | No | No | No | Considerable |
| Response to reasons advanced for space infrastructure[c] | | | | | | |
| Maintain U.S. space leadership and technology capability | No | Modest | Modest | Modest | Considerable | Extensive |
| Respond to U.S.S.R. space activities | No | Modest | Modest | Modest | Considerable | Extensive |
| Enable long-term human presence in space | No | Modest | Modest | Considerable | Extensive | Extensive |
| Attention-getting heroic public spectacle | No | Modest | Modest | Modest | Modest | Modest |
| Extended international cooperation | Modest | Modest | Moderate | Moderate | Moderate | Moderate |
| Promote U.S. commercialization of space | Modest | Modest | Modest | Considerable | Considerable | Considerable |
| Maintain vigorous NASA engineering capability | No | No | No | Modest | Extensive | Extensive |
| Enhance national security, broadly defined | No | No | No | Modest | Unclear | Unclear |
| Space travel for non-technicians | Modest | Modest | Modest | Modest | Considerable | Considerable |

[a]Listed options are illustrative examples; the list is not exhaustive.
[b]Costs include design, development, and production; launch and operational costs are not included. Some costs are estimated by the Office of Technology Assessment; others were provided to OTA.
[c]Clearly judgmental.
[d]Including launch to the Moon, Mars, and some asteroids.

**Table 2.—Space Infrastructure Platforms[a] That Could Be Serviced by Shuttle or an Orbital Maneuvering Vehicle**

| | Unpressurized coorbiting platforms (serviced by means of extravehicular activity) | | | | Pressurized platforms (serviced internally while docked) | |
|---|---|---|---|---|---|---|
| | SPAS | MESA | LEASECRAFT | EURECA | Space Industries' Platform | European Modified Spacelab |
| Data available (now, or approximate, assuming start in 1985) | Now | Now | 1986 | 1987 | Late 1980's | 1989 |
| Cost[b] (billions of fiscal year 1984 dollars) | 0.005 | 0.01 | 0.2 | 0.2 | 0.3 | 0.6 |
| Characteristics | | | | | | |
| Power to users (kW) | 0.6 | 0.1 | 6 | 2 | 20 | 6 |
| Pressurized volume ($ft^3$) | None | None | None | None | 2,500 | 3,000 |
| Nominal crew size | None | None | None | None | 1–3 only when docked | 3 |
| Miscellaneous | 3,000 lb Payload | 200 lb Payload | 20,000 lb Payload | 2,000 lb Payload | 25,000 lb Payload | 20,000 lb Payload |
| Capabilities[c] | | | | | | |
| Time on orbit | 10 days | 6 months | Unlimited | 6 months | 3–6 months | Unlimited |
| Laboratories for: | | | | | | |
| Life sciences | No | No | Modest | Modest | Modest | Moderate |
| Space science/applications | Modest | Modest | Modest | Modest | No | Moderate |
| Materials science | Modest | No | Modest | Modest | Moderate | Moderate |
| Technology development | No | No | Modest | Modest | Moderate | Modest |
| Observatories | No | No | Modest | Modest | Modest | Moderate |
| Data/communication node | No | No | No | No | No | No |
| Servicing of satellites | No | No | No | No | No | No |
| Manufacturing facility (materials processing) | No | No | Considerable | Modest | Extensive | Considerable |
| Large structure assembly | No | No | No | No | No | No |
| Transportation node (assembly, checkout, and launch) | No | No | No | No | No | No |
| Fuel and supply depot | No | No | No | No | No | No |
| Response to reasons advanced for space infrastructure[c] | | | | | | |
| Maintain U.S. space leadership and technology capability | No | No | Modest | No | Modest | No |
| Respond to U.S.S.R. space activities | No | No | Modest | No | Modest | Modest |
| Enable long-term human presence in space | No | No | No | No | No | No |
| Attention-getting heroic public spectacle | No | No | No | No | No | No |
| Extended international cooperation | Yes | No | No | Yes | No | Unclear |
| Promote U.S. commercialization of space | Unclear | Modest | Considerable | No | Considerable | No |
| Maintain vigorous NASA engineering capability | No | No | No | No | No | No |
| Enhance national security, broadly defined | No | No | No | No | No | No |
| Space travel for nontechnicians | No | No | No | No | No | No |

[a]Listed platforms are illustrative examples; the list is not exhaustive.
[b]Costs include design, development, and production; launch and operational costs are not included. Some costs are estimated by the Office of Technology Assessment; others were provided to OTA.
[c]Clearly judgmental.

**Table 3.—Some Illustrative Space Infrastructure Acquisitions Possible at Various Annual Average Federal Funding Rates (all amounts in billions of 1984 dollars)**

| Funding rate ($/yr) | Number of years | Total expenditures ($) | Space acquisitions[a] | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dependent elements | | | |
| | | | Independent infrastructure elements[b] | Unpressurized platforms[c] | Pressurized platforms[d] | Space-based transport vehicles | Beyond geostationary orbit spacecraft elements |
| 0.1[e] | 5 | 0.5 | EDO I[f] (20 days, 5 crew) | 2 | — | — | — |
| | 10 | 1 | EDO II (50 days, 6 crew) | 3 | — | — | — |
| | 15 | 1.5 | EDO II (50 days, 6 crew) | 3 | 1 | — | — |
| 0.3 | 5 | 1.5 | EDO II (50 days, 6 crew) | 3 | 1 | — | — |
| | 10 | 3 | Free-flying Spacelab modules[f] (permanent, 3 crew) | 1 | 1 | OMV | — |
| | 15 | 4.5 | 2 free-flying Spacelab modules in both 28 degree and polar orbits (3 crew each) | 2 | 1 | OMV | — |
| 1 | 5 | 5 | Space transportation center (4 crew) | — | — | OMV; ROTV | — |
| | 10 | 10 | NASA initial operating capability "space station"[g] (8 crew) | 2 | 1 | OMV; ROTV | — |
| | 15 | 15 | NASA growth "space station"[g] (12 crew) | 3 | 1 | OMV;ROTV | — |
| 3 | 5 | 15 | NASA growth "space station"[g] (12 crew) | 3 | 1 | OMV; ROTV | — |
| | 10 | 30 | NASA mature "space station"[g] (16 crew) Shuttle-Derived Cargo Vehicle (SDV) | 3 | 2 | OMV;ROTV | Lunar capable ROTV; staffed Lunar facility |
| | 15 | 45 | NASA mature "space station"[g] (16 crew, SDV) | 5 | 3 | OMV; ROTV | Lunar capable ROTV; staffed Lunar facility; Mars voyage[h] |

[a]Tables 1 and 2 present characteristics and capabilities of infrastructure elements in detail.
[b]Extended Duration Orbiters (EDO) are limited in their stays on orbit; other independent elements are long-term.
[c]Platforms of the LEASECRAFT/EURECA type.
[d]Platforms of the modified free-flying Spacelab/Space Industries type with their own electrical power and pressurization systems.
[e]At $0.1 billion/yr, no long-term, staffed infrastructure elements are possible.
[f]EDO I (Extended Duration Orbiter, Phase I) and the Spacelab modules have limited electrical power (about 7 kW).
[g]The NASA "space station" elements are expected to operate as transportation and servicing centers as well as laboratories. They would have sufficient power for extensive materials processing.
[h]A significant part of the cost of a human visit to Mars could be provided in this case.

## Table 4.—Possible Goals and Objectives

| | Goals | | | | | | |
|---|---|---|---|---|---|---|---|
| | Increase space activities' efficiency; reduce their net cost | Involve the general public directly | Derive economic benefits | Derive scientific, political, and social benefits | Increase international cooperation | Study and explore the physical universe | Bring life to the physical universe |
| Objectives: | | | | | | | |
| 1. Establish a global information system/service re natural hazards | N | N | P | Y | Y | N | N |
| 2. Establish lower cost reusable transportation service to the Moon and establish human presence there | Y | P | P | Y | Y | Y | Y |
| 3. Use space probes to obtain information re Mars and some asteroids prior to early human exploration | N | N | N | Y | Y | Y | N |
| 4. Conduct medical research of direct interest to the general public | N | N | P | Y | P | N | N |
| 5. Bring at least hundreds of the general public per year into space for short visits | N | Y | Y | Y | Y | N | Y |
| 6. Establish a global, direct, audio broadcasting, common-user system/service | N | P | P | Y | Y | N | N |
| 7. Make essentially all data generated by civilian satellites and spacecraft directly available to the general public | N | Y | P | Y | Y | N | N |
| 8. Exploit radio/optical free space electromagnetic propagation for long-distance energy distribution | N | N | Y | P | Y | N | N |
| 9. Reduce the unit cost of space transportation and space activities[a] | Y | N | Y | Y | N | N | N |
| 10. Increase space-related private sector sales[a] | Y | N | Y | N | N | N | N |

[a]This would advance the prospects of successfully addressing all other "goals."

Y: Yes; N: No; P: Perhaps; depends on how carried out.

**Table 5.—Cost and Schedule to Satisfy Objectives Suggested for Discussion**

| Objectives | Total cost[a] (billions, 1984 dollars) | Duration (years) |
|---|---|---|
| 1. Establish a global information system/service re natural hazards | 2 | 10 |
| 2. Establish lower cost reusable transportation service to the Moon and establish human presence there[b] | 20 | 15, 25 |
| 3. Use space probes to obtain information re Mars and some asteroids prior to early human exploration[c] | 2 | 15 |
| 4. Conduct medical research of direct interest to the general public[d] | 6 | 5, 25 |
| 5. Bring at least hundreds of the general public per year into space for short visits[e] | 0.5 | 5, 25 |
| 6. Establish a global, direct, audio broadcasting, common-user system/service | 2 | 10 |
| 7. Make essentially all data generated by civilian satellites and spacecraft directly available to the general public | 0 | 25 |
| 8. Exploit radio/optical free-space electromagnetic propagation for long-distance energy distribution[f] | 0.5 | 10 |
| 9. Reduce the unit cost of space transportation and space activities[g,h] | 5 | 15 |
| 10. Increase space-related private sector sales[h] | 0.5 | 25 |
| | ~$40[i] | |

[a] Costs are for development and acquisition. Operations and maintenance costs are not included, except for some launch and operations costs noted for objectives 2, 3, and 4.
[b] 15 years to establish the settlement, and 3 visits/year at $0.1 billion each (plus basic Shuttle launch costs) over the following 10 years.
[c] On the average, one probe every 3 years and $0.4 billion each.
[d] $2 billion over 5 years to establish a life sciences laboratory in LEO, and $0.2 billion/year thereafter to operate it. This laboratory could also be used for materials science and other research.
[e] 5 years to establish a LEO "lodge-habitat," and its continuing use thereafter.
[f] $0.05 billion/year in addition to DOD expenditures.
[g] $0.3 billion/year for a 15-year technology development effort to reduce space transportation unit costs.
[h] This would also help efforts directed toward the other objectives.
[i] The actual cost could be as high as $60 billion (1984 dollars), if costs exceed initial predictions by 50%.

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*Through September 1983.
**After September 1983.

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*Published November 1984

April 27, 1987

Office of Technology Assessment

ANSWERS TO COMMITTEE QUESTIONS RE: SPACE STATION

1) How flexible are the technologies NASA is investigating and how much of the phase B work might be applicable to some new configuration or assembly?

As we noted in our study, *Civilian Space Stations and the U.S. Future in Space*, the NASA design is only one of many possibilities for permanently inhabited space infrastructure. Other designs are certainly possible, depending on the capabilities that are desired and the budget that is available.

It should be possible for NASA to build on the work it did in the phase B studies because much of the technology involved is generic, and would be applicable to any particular design. For instance, NASA's contractors have learned about life support systems, docking mechanisms, habitable structures, and power generation systems, to name a few. Much of what they have learned in the phase B studies could be transferred to a variety of specific space station designs. In particular, items like power supplies are being designed as modular items, which can be changed or upgraded over time as new technologies enable system improvements.

**2) What would be the benefits and drawbacks of imposing a funding envelope of the type we propose on NASA?**

*BENEFITS:*

The greatest benefits such a funding envelope could impart would flow from the sense of predictability and stability it would give to NASA's budget. Seen from the vantage points of NASA and the Congress, such a plan would have the benefit of specifying a predictable budget for the next 10 years or so. It would be easier for NASA to plan for specific staff and procurement expenditures during the construction and initial operation of a space station. Congress would be relieved of the onerous task of balancing specific space station line items against one another in the yearly budget and could focus its attention on the overall space station plan and how best to meet the needs of users and the American public as a whole.

There are numerous other benefits as well. The Committee's funding envelope might make it possible for NASA to to avoid attempting to set and meet unrealistic deadlines; it would protect the budget for space science and applications, as well as space transportation and other non-space station expenditures; it could encourage NASA to seek greater private-sector contributions to a space station, and to explore ways to keep eventual operating costs down.

Such an approach might assist NASA in developing cost cutting approaches in other areas. If NASA could save on other areas, say space transportation, by saving a mission or two to the space station, it could apply that saving to space station development.

*DRAWBACKS:*

There is one major drawback to a flat funding envelope--most multi-year projects have been designed to fit into a funding pattern that starts small, rises to a peak, and falls again. Fitting such a project into a flattened budget envelope would require careful planning. Allowing NASA to defer part of any year's spending authority to following years would, of course, ease this problem. A likely, but not certain, outcome of this funding envelope is a stretchout of the time at which a station could be permanently inhabited. As we note in answer to question (14), our international partners are likely to have concerns over stretching the time scale of availability for a station. It might strengthen hands of those in Europe who would like greater autonomy for the Columbus program.

However, the Committee's funding envelope need not stretch out the time at which a man-tended, as distinct from a permanently inhabited, platform could be available for much needed experiments on materials and space science observations. Indeed, appropriate planning, and careful attention to the requirements of our international partners, might allieviate

their concerns by making it possible to include their contributions before a space station became permanently inhabited.

**3) How do you see the Space Station, and the Committee proposal, affecting NASA's future and U.S. leadership?**

Nothing less than the future of the civilian space program is at stake in the debate over the funding for a space station. If the United States wants to continue its progress in the exploration and development of space, this country will need to build substantial in-orbit infrastructure. However, if NASA proceeds on a path whose future budgetary requirements are larger than the Congress wishes to accept, the country would be in danger of forcing later delays or of putting other important programs in jeopardy. A more conservative approach, that fits projected budget constraints more comfortably and, to the extent possible, responds stepwise to user requirements as they become verified could give this Nation and the world the assurance that NASA is once again on track.

**4) What role would the Space Station, and the Committee proposal, have on U.S. competitiveness and a potential mission to Mars?**

As we noted in OTA's 1985 report on *International Cooperation and Competition in Civilian Space Activities*, the United States faces serious and sustained competition in space science, space applications, and space transportation from Europe and Japan, as well as the Soviet Union. China is also fast becoming a space power, and is offering space transportation services in direct competition with other international systems. Yet, "U.S. policies have not adapted fully to the effects of increased foreign competition, nor, outside of satellite telecommunications, has the United States developed ways to involve its private sector effectively in applications of space technology,"[1] including space transportation.

Although building and operating a space station would demonstrate leadership in one important area, it would not necessarily maintain our competiveness in space with the other industrialized countries. Indeed, to take just one example, many of OTA's contacts in other countries are bemused or saddened by the apparent failure of our Landsat program. They wonder at our unwillingness to pursue a program that appears to have had good prospects for relatively near-term payoffs. Meanwhile, the French have launched their SPOT satellite and are selling high

1 *International Competition in Civilian Space Activities*, p. 3.

resolution data to a variety of customers around the world. And the Japanese have just launched a very capable ocean remote sensing system.

Other possible space station technologies and science activities that could enhance U.S. competitiveness include automation and robotics; space science; astrophysics; biology, and space medicine; materials science; and Earth observations.

In addition, if the country should accept the long-term goal of a manned Mars mission in the early 21st century, as recently recommended by the National Commission on Space,[2] or some other major space activity, the United States will have to provide additional resources, which could be considerable. If the costs of the space station activity were already straining NASA's resources, they could seriously impair NASA's ability to mount such a mission.

5) When OTA performed its 1984 study, what assumptions did you make concerning the growth in the funding wedge that would be available for Station? How does this compare with the current situation?

Based on NASA's 1984 budget, OTA assumed that after shuttle development was complete, the approximately $2 billion then expended annually for shuttle development costs could be released for use in space station development.[3] However, a recent

2 National Commission on Space, *Pioneering the Space Frontier*, (New York: Bantam Books, May 1986).

3 *Civilian Space Stations and the U.S. Future in Space*, pp. 225-26.

Congressional Budget Office working paper makes clear that it will be necessary to continue to spend monies on shuttle development and that a funding wedge from this source will not be available for at least 5 years.[4] It is not apparent that there will be savings in other portions of NASA's budget either.

Thus, in order to provide any major new space infrastructure, including space station components or new space transportation capabilities, Congress will have to add money to NASA's budget. The '87 budget is about $8.5 billion, not counting the extra $2.1 billion in this year's budget to replace Challenger.

6) **What interaction do you see between the Station and other major activities within the NASA budget?**

It is vitally important, both to the U.S. space program as a whole and to U.S. competitiveness in high technology, to keep all elements of the overall NASA effort--space science, space transportation, materials processing--alive and well. Large projects on fixed time scales tend to be risky. Miscalculation of costs cannot be met by stretchout, so, if budget totals cannot rise, large projects can crowd out their neighbors. As noted already, the shuttle "wedge" has not materialized. It was this wedge that was supposed to make other capabilities, including space station, possible, as we gained experience with the shuttle.

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4 Congressional Budget Office, "The 1988 Budget and the Future of the NASA Program," Staff Working Paper, March 1987.

**7) What effect do you think it would have if we fully defined the operation and growth costs for the Station after the initial deployment is complete?**

In OTA's view, realistic estimates of the operations costs for potential space infrastructure elements are an essential input to the choice of which elements will be acquired, when, and in what sequence. If they aren't well defined ahead of time, we could reach a situation similar to that of the shuttle, which requires a large workforce to keep flying. One of the points the aerospace contractors have made over and over to us is that reducing the costs of space transportation substantially will require reducing the costs of processing the orbiters and their payloads. The same would be true for the operating costs of the space station. In other words, by assessing the operational costs of different potential capabilities today, NASA could begin to make tradeoffs among space station elements, and overall design alternatives for the future.

In order to arrive at a realistic overall picture, reliable estimates of the utilization costs of space station elements are also needed, regardless of the choice of budget line on which they are ultimately to be entered. Although we have not estimated the operational costs of a space station, comparisons with other large scientific and engineering projects suggest that they could be expected to be from 10% to 15% of the development costs per year. Therefore, over a ten year operational period, operations costs could dominate overall costs.

In the space area, as in other high technology areas, it is probable that there are some capabilities that could be acquired but would turn out to be too expensive to use. The design of the Shuttle -- its mix of capabilities -- might have been quite different if today's estimates for its operations costs had been included as part of the design process.

Because operations and utilization costs are such important factors, it is especially important to choose space infrastructure elements that respond to reasonably "hard" utilization requirements: it is very expensive to develop operational capabilities on speculation that they may become important some time in the future. That is not to say, however, that possible future uses can be ignored. It is clear that utilization requirements will evolve over time. Therefore, while building for the reasonably sure uses, it is equally important to leave room for graceful evolution toward new capabilities as these become necessary.

8) Is it feasible for Congress to adopt a design to cost approach set at, say, a total cost of $15 billion spent at $1.5 billion per year?

In OTA's view, a design-to-cost approach is a sensible way to proceed. And if future year budgets remain as tight as today's it may be the only way to acquire the capabilities of a space station without adversely affecting or even cutting out other NASA programs.

Acquiring space infrastructure elements is best seen as an evolutionary process, driven by the desire to achieve new space capabilities, constrained by availability of funds, and guided by judgment of relative merit of candidate possibilities. Space infrastructure is not the sort of thing that can be obtained once and for all.

In Table 3 on page 12 of our November '84 report, we estimated that, in 1984 dollars, $1 billion per year for 10 years would allow the purchase of an 8 crew space station along with an orbiting maneuvering vehicle, and a reusable orbiting transfer vehicle. Our estimates were reviewed by the study's Advisory Panel, NASA, and outside experts, but, in light of NASA's recent escalation of its estimates, it is clear that our figures would also have to be revisited. That is, we cannot assert that after, say, 10 years, having spent $1.5 billion per year, we will have a "complete" space infrastructure. What OTA can say is that a space station program, proceeding at an annual expenditure rate of $1.5 billion per year for 10 years, could produce very substantial, useful space infrastructure that, if designed with operating costs in mind from the beginning, the United States could afford to operate.

If the Committee chooses to pursue this design to cost approach, it will have to ask NASA to fill in the details over the next six months to a year. It is important that the plan requested from NASA by the Committee include the following:

estimates of costs of construction of the space station, its eventual operations and maintenance costs, the kind and cost of space transportation it will need during construcion and operation, what additional resources are needed as a function of its utilization, and other peripheral costs and activities.

9) **At an average funding rate of about $1 billion to $1.5 billion per year, what kind of capabilities could we achieve in 10 to 15 years?**

This is where the term space infrastructure is so important. Table 3 of our report, *Civilian Space Stations and the U.S. Future in Space*, provides several alternatives that are possible, depending on user needs. As we note in our answer to the previous question, even though this table was extensively reviewed in 1984, the figures in it may be subject to the same kind of corrections that have led NASA to revise its estimate of the cost of its proposed space station upward from $8 billion to $15 billion or more.

There are different approaches to developing space, depending on what the Nation wants to do there and on Congress' perception of the capabilities that would best indicate America's leadership in space. The path to a manned landing on Mars is not the same as the path to a space-based materials processing industry--and neither is it the path that leads to enhanced global monitoring capability, or to aggressive exploitation of the best ideas of our space scientists.

Assume for the moment that the goal itself is a space station. Even under this circumstance, there are choices, depending on urgency, cost constraints, willingness to fail, and the desired objectives of space development. Once could proceed quickly to develop and deploy a permanently inhabitable facility, satisfying, if successful, pressures to have U.S. capability to live in space. Alternatively, one could build a station that is initially man-tended, rather than permanently inhabited. In this case, such a structure could quickly provide an ability to pursue experiments and observations in space science, astronomy, space manufacturing, biology, and certain kinds of space medicine. Using such a capability for a time would give NASA important experience that could be used in developing capability for permanent habitation at a later date. Although a shirt sleeve environment may be important for long-term experimentation in space, there are many experiments and prototype manufacturing facilities that could be set up in one or more free flying servicable platforms.

America could certainly achieve a permanently inhabited space station in perhaps 10, and certainly, 15 years by any of several paths. However, if the country decides that it needs one prior to that, it may well be necessary to spend more than $1.5 billion per year.

**10) In your 1984 study, what role did the private sector play in the various acquisition scenarios you looked at?**

To date, most private sector investment in space has been in satellite communications and in supporting government activities. *Civilian Space Stations and the U.S. Future in Space* points out that because the nation's investment in space will continue to be driven by government needs, the government will continue to be the major purchaser of any private-sector goods and services. Our report went on to say that if NASA and other agencies encouraged the private sector to invest in space facilities, the private sector could be a major player. We noted at the time that there seemed to be increasing interest among private companies in providing various portions of the total space infrastructure. (Examples are upper stages, launch vehicles, remote sensing, and most recently, a major space laboratory built using the shuttle external tanks.) Our study also noted that the matter of private investment in space "is not receiving all the attention within the Executive Branch that it warrents, except perhaps at the highest levels."[5]

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5 *Civilian Space Stations and the U.S. Future in Space*, p. 38.

**11) Given the present state of technology for automation and artificial intelligence, what level of automation can we expect to see on the space station and its ground facilitites within the next decade? How could a higher level of automation affect operation costs?**

OTA held a workshop on automation and robotics (A&R) in 1985 and published a staff paper entitled, "Automation and Robotics for the Space Station: Phase B Considerations." We concluded then that "NASA is not planning to use space station program money for A&R research except in a few selected areas where it cannot be avoided." We also concluded that "the only A&R research NASA plans to undertake lies in the Office of Advanced Space Technology (OAST) program...As currently funded and managed, OAST's A&R research is not likely to have a strong impact on space station capabilities or on the state of the art in terrestrial automation."[6]

By contrast, for example, the German space program is very interested in A&R. That program takes as a given that, "permanent -- and especially permanently manned -- space facilities cannot be successful without extensive use of advanced A&R technologies."[7] The Germans are developing a program to exploit A&R capabilities in their work on Spacelab and on the European contribution to the space station.

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6 "Automation and Robotics for the Space Station: Phase B Considerations," p. 4.

7 Deutsche Forschings- und Versuchsanstalt fur Luft- und Raumfahrt, "Automation und Robotik im Zukunftigen Deutschen Raumfahrt-Programm," p. 4.

Currently, ground-based A&R is more advanced than any space-based A&R. Studies in Germany and the U.S. have identified space activities -- because of extreme environmental conditions and corresponding operational requirements -- as an appropriate focus for advancing the state of the art in many aspects of A&R. Two important conclusions follow: 1) in the near-term, the flow of technology has to be from ground to space, but 2) in the longer term, the technology could flow in both directions. That is, space A&R could be a technology driver of significant importance for terrestrial practice.

A space station and its related ground facilities, developed within the next decade, could include a level of A&R approaching the state of the art of ground-based A&R facilities. A key goal in planning for the specific A&R capabilities to be developed is to make the in-orbit facilities increasingly independent of the need for detailed supervision from the ground. Thus, in space and space-related facilities, the A&R capabilities might include:

- o decentralized knowledge-based systems, on board and on ground, for tasks such as health and fault maintenance and crew activity planning;
- o robotic systems with cooperating manipulator arms for external servicing; and
- o a suite of internal robotic systems for experiment manipulation.

Estimates of the cost of crew time in orbit are on the order of several tens of thousands of dollars per hour. In addition, crew time will be limited. In these circumstances, the addition

of appropriate A&R capabilities would seem to offer considerable opportunity for improving the productivity of the station. More widely viewed, advanced A&R capabilities show significant promise of driving down the operational costs of a station. Although development costs of such capabilities would be substantial, the reduction in operations costs flowing from the introduction of advanced automation and robotics would almost certainly make up for initial expense.

12) **Could the U.S. build a station for $15 billion that would be competitive with the Soviets?**

This question goes directly to the heart of an important aspect of the current space policy debate -- U.S. leadership compared to the Soviet Union. World leadership is elusive and hard to quantify. Some want to compare the NASA effort with the Soviet Union's by comparing kilograms and kilowatts in orbit, but this is not necessarily the way leadership is earned. Nor is it earned by achieving the most days in orbit. Leadership depends on using the unique capabilities of space infrastructure to achieve scientific, economic, and humanitarian goals. U.S. leadership will be earned, as it has been in the past, by thoughtful integration and management of all of the U.S. resources, whether terrestrial or space-based, and skillful use of technologies in which we excel. For example, by emphasizing automation and robotics for the space station, and thereby pushing the state of the art, the United States could stay ahead in those highly competitive and important areas.

U.S. leadership in space cannot be measured by a space station activity alone. For example, between now and the time a U.S. space station is operable, some $70-100 billion is projected to be spent by NASA for existing science and applications programs and for space transportation. A $15 billion addition to this, whether earmarked for a space station or not, should increase the likelihood that our civilian space infrastructure will be more capable than the Soviet's by the late 1990s.

13) In terms of technology development, do we know enough now to plan for a meaningful program in materials processing and life science aboard a space station in 1994? What would we need to do to prepare ourselves for such a meaningful program?

Unfortunately, the United States does not yet know enough to plan for a detailed, meaningful program. As the Congressional Budget Office recently pointed out,[8] not having the shuttle available to carry out a variety of science missions has prevented NASA from gathering crucial data that could guide the design of specific elements of the space station. The proponents of a space station have long argued that this country needs a permanently manned facility to reap the benefits of experimentation and manufacturing in a low gravity environment. The shuttle, using the European-built spacelab, can demonstrate many of these activities, but even when it begins flying again in 1988 or 1989, because of other priorities, the shuttle will be able to mount only a few missions using spacelab.

8 "The 1988 Budget and the Future of the NASA Program," op. cit.

Such experiments would also help the U.S. stay competitive with other space capable nations, especially the Soviet Union. Soviet scientists, for example, may be far ahead of us in their understanding of the life sciences in space. We could enhance our ability in this one area significantly by flying experiments on the shuttle. However, the most recent post-recovery shuttle manifest we have seen is constrained with respect to science.

14) What impact would our authorization potentially have on our international partners?

Several years ago, the United States lobbied hard with our traditional international partners in space activities--Canada, ESA, and Japan--to solict their contributions to a space station. Though initially reticent, they decided that contributing to an international space station, with the United States taking the lead, was in their best interests.

As we noted above, it is likely that a design-to-cost approach at the level suggested by the Committee would entail following a more even and more stretched schedule for orbiting and operating space infrastructure. Any charges that stretch out the timetable of a space station program will certainly affect the plans of our foreign partners and possibly increase their costs. On the other hand, they are not strangers to the philosphy. In particular, Columbus, ESA's program to contribute to develop European in-orbit infrastructure and to contribute to the international space station program, has been undertaken on a

design-to-cost basis. The Ministerial Council meeting of January 1985 set a ceiling of 2.6 Billion Accounting Units for total development and initial operating costs of Columbus elements. Over the succeeding two years, the content of the Columbus Program has undergone substantial revision. (Currently, the Program foresees three major elements: an attached pressurized module, a polar platform, and a man-tended freeflying laboratory.) In principle, therefore, the Europeans could hardly object to a NASA approach resembling their own.

However, ESA is now gearing its Columbus planning to NASA assurances that the European pressurized module (the APM) can be attached to the core station in 1994-5. Given the fact that NASA's assembly sequence foresees the APM, as well as the Japanese Experiment Module (JEM), being added to the station in the last phase, the Committee proposal could mean a 2-3 year delay for Europe and Japan. Our international partners would likely interpret such a delay as a significant setback, and, depending on how they respond, a delay could lead to some cost increases for the Europeans. Yet, there are those in Europe who consistently and forcefully argue that U.S. space policy and planning are so subject to radical and unexpected changes that Europe must proceed directly to the development of its own autonomous capabilities. It is quite possible that Europe would welcome a U.S. approach that makes for a steady, more evenly paced, and -- most important -- more calculable program, that fits better into U.S. budget constraints. In other words, if the

Europeans believed that the United States was making a fundamental shift to a steady, long-term funding perspective, and that neither OMB nor Congress would seriously challenge the $1.5 billion per year in the future, then this would be an argument in favor of continued cooperation with the United States. The same line of argument could be applied to the reactions of Japan and Canada.

The United States might be able to limit some of the consequences of a stretched schedule on our international partners by developing another assembly sequence in which the plans of the international partners are not so heavily affected.

These considerations do not militate against the Committee budgeting proposal per se. Rather, they argue that U.S. space planning must balance U.S requirements with important concerns of those nations invited to participate in the international space station.

Mr. NELSON. The Subcommittee is adjourned.

[Whereupon, at 5:11 p.m., the Subcommittee recessed, to reconvene at the call of the Chair.]

76-600 O - 87 -31

# 1988 NASA AUTHORIZATION

THURSDAY, APRIL 23, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 9:40 a.m., Hon. Bill Nelson [chairman of the subcommittee] presiding.

Mr. NELSON. Good morning. A couple of announcements. At 5:00 p.m. tonight in this room, the Subcommittee is sponsoring a symposium for members and staff on the Super Nova 1987-A. Dr. David Helfand, who is an astro physicist from Columbia University, will present a lecture. This seminar is sponsored by the American Astronomical Society, and then there will be a reception after the lecture. At one point—the second announcement is at one point we thought many moons ago that we might be having a mark-up next Tuesday, but there are so many things to still be juggled and to be worked out, so the mark-up is going to be postponed.

Now today is another one of the series of hearings on the NASA budget request, and the focus of today's hearing is going to be on the competition in the solid rocket motor program.

For several years the subcommittee has been closely monitoring NASA's progress, and has been encouraging the agency to finally resolve the issue of whether or not there should be a competition in this program. This has been going on for years.

A key unknown has been the precise determination of whether competition in this program would actually save money, or in fact whether it would actually end up costing the government more in the long run.

Well, in last year's authorization bill, we directed NASA to develop and present to the Congress a detailed acquisition strategy and plan for the continued procurement of solid rocket motors for the shuttle. And so at today's hearing NASA will be presenting that plan.

Our objective today then is to scrutinize this plan to better understand its strengths and weaknesses, and to discuss the range of alternatives that the agency has evaluated in the process.

Now this is a crucial topic in the overall recovery effort for the shuttle. Obviously involved are issues of safety, cost and performance, and if everyone collectively makes the right decisions in the coming weeks and months, then the program is going to be strengthened. If anybody makes the wrong decision, then it could be tube city. So to help us in this process today, we have one of the finest leaders in NASA, Admiral Truly, accompanied by a very dy-

namic new leader of the Marshall Space Flight Center, J. R. Thompson, and so we are delighted to have you here today to discuss this plan.

Let me turn to our ranking member, Mr. Walker, for his comments.

Mr. WALKER. Thank you, Mr. Chairman. I, too, warmly welcome Admiral Truly and J.R. Thompson to the hearing this morning.

This morning, as you stated, we will examine the NASA proposal for the advanced solid rocket motor for the space transportation system. I strongly believe that we should examine this proposal and move forward into Phase B so that we can determine if the ASRN program makes long term sense. This is a proposal that can make the space transportation system more reliable, improve safety margins, reduce the potential risks to flight crews, and enhance performance margins.

The Congress owes the men and women of our space program adequate resources to make manned space flight as safe as possible.

Mr. Chairman, I would ask unanimous consent that the entire opening statement I have here be included in the record.

Mr. NELSON. Without objection.

Admiral Truly.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS OF
REPRESENTATIVE ROBERT S. WALKER

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
APRIL 23, 1987

Good morning, Mr. Chairman. And a warm welcome to Admiral Truly. This morning we will examine a NASA proposal for an Advanced Solid Rocket Motor for the Space Transportation System.

This proposal is in response to repeated demands from the Congress to NASA to introduce competition into the procurement of solid rocket boosters for the Space Shuttle. There are many Members of the House, and also of the other body, who believe that competition is healthy and may result in savings to the taxpayer.

I strongly believe that we should serve as watchdogs of the treasury. But we have an equally important duty to oversee the programs of NASA to ensure that they are conducted in a manner that will ensure flight safety. In the present case I am pleased to say that this proposal not only appears to have been carefully crafted to give all potential bidders in the Advanced Solid Rocket Motor program an even playing field, but we also have before us a program that will enhance operational safety and increase performance of the Space Transportation System.

The most important message that this Committee should have learned from the Challenger disaster is that flight safety must be our primary consideration. At the flight rates that we all now recognize the STS will be flying for

the forseeable future, we simply cannot compromise safety and quality control.

I strongly believe that we should examine this proposal, and move forward into Phase B, so that we can determine if the ASRM program makes long term sense. This is a proposal that can make the Space Transportaion System more reliable, improve safety margins, reduce the potential risks to flight crews, and enhance performance margins. The Congress owes the men and women in our space program adequate resources to make manned space flight as safe as possible.

**STATEMENT OF ADMIRAL RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC. ACCOMPANIED BY JAMES R. THOMPSON, DIRECTOR, MARSHALL SPACE FLIGHT CENTER**

Admiral TRULY. Good morning, Mr. Chairman, and thank you for inviting us up here today to discuss this subject. It is one that is very important to us. We worked very hard at it, and I'm pleased to be here.

With your permission, I would like to enter my statement into the record, and just make a few slightly more informal comments, and tell you something about the proposal.

First of all, let me say that I believe that the most important thing in the civil space program is that over the period of the next several years is to get our space transportation department back into shape and to correct those things that need correcting. It is going to involve a lot of things: getting the shuttle back to first flight, stabilizing at a safe and sustainable flight rate. It's going to involve expandable launch vehicles, and an important part of that is the approach that we take in response to the Congress' direction on what to do about the solid rocket motor system. And that is what I would like to go through just for a few moments.

I think we have provided for you an informational packet, I'm not going to go through each of these, but I would like to go through a limited number of the items in this package to tell you a little bit about the space shuttle advanced solid rocket motor.

As a part of this study, first of all, we looked very carefully at the Congressional direction that we got, in the urgent supplemental and in the authorization. We looked at, frankly, many options. We boiled them down to three options that I'd like to describe to you so you will understand, that they do in essence capture the various types of approaches that we could have taken.

We did develop an acquisition strategy, and we do have a plan. We know what to do, and we are anxious to move ahead.

If I could have the next viewgraph, please.

The three options that we boiled down this study to are shown on the screen to your left.

The first option is to look at what has been referred to as a second source. In other words, take the redesigned motor that will emerge from the accident into the pre-design when we get flying again, and have a competition, and open that competition to people so that we could develop, qualify and certify another contractor other than our present prime contractor, and then split the buy between the present contractor and the newly qualified one; or alternatively, phase out the present prime contractor and have the new contractor win. And that would be a competition.

In order to evaluate this whole thing, the second option that we have tried to label for you is what it would be if we had no change to our present contractual situation. That is, Morton-Thiokol continue production of the redesigned solid rocket motor indefinitely, and the reason that I wanted to be sure and lay that out is that if we do nothing, of course, that is our position, and there's a lot of business between now and when I think the shuttle will be finally

retired in 2005 and 2010, and so it is important to concentrate on the deltas from that baseline.

The third option that we finally looked at, and are heartily recommending, is to take this opportunity to upgrade the solid rocket motor hardware for various reasons that I will mention, and also to gain some performance that we sorely need—I can discuss that with you at length during the hearing—and to do this in the environment in fair and open competition, which would at the very start of it, would not favor any contractor over another. We think we have studied it enough to believe that it is a rational and logical way to go, and would help us in the last 15 or 20 years of using the shuttle, and is an integral part of the transportation strategy.

Could I have the next slide.

This proposed acquisition strategy and plan is shown on this viewgraph.

First of all, what we need to do is to develop a data base so that we can move out into a development and production contract on this advanced solid rocket motor. We intend, within funds available within NASA, to initiate what we refer to as Phase B engineering contracts.

We would look at both monolithic and case-segmented designs in this Phase B.

Mr. NELSON. Okay, hold on just a second.

Admiral TRULY. Pardon me.

Mr. NELSON. If you are having difficulty seeing, we can do one of two things: We can shut out the lights or, in the alternative, you can turn to about the fourth page on your handout. All right. It's the one—proposed ASRM acquisition strategy and plan. Okey-doke.

Admiral TRULY. Thank you, Mr. Chairman.

As I was saying, the first thing that we need to do is to go out in some serious Phase B engineering studies that would involve the qualified contractors, and we would look at both a monolithic and a case-segmented design.

We would also initiate systems performance studies so that we could take a look at the effect that this motor would have on the system, so that at the time that we went out and issued an RFP and had a competition, we would be sure that all the analysis that would have to be done in the ascent phase would have been properly addressed.

And, frankly, this would also provide the source evaluation board with data that's not now available on monolithic design, because that is a design that we think holds promise after doing the so-called Block 2 studies that we did. But it is a design that has not flown before in this size of a motor, and we believe the Phase B would provide the board with that kind of a data base.

The next thing that we need to do, obviously, is to prepare a justification for the FY 1989 budget, including a plan to move out on a possible Phase C and D. In other words, development and production of the advanced solid rocket motor. This competition would stress full and open competition to all comers. It would have emphasis on a modernization of our facilities, and try to move the industry into better processing techniques and automation.

We would ask that the contractors consider locating the plant on federal property, and we would study that during the coming year

to see if the advantages that J.R. Thompson feels strongly about on that idea would hold fruit, and whether that should be a part of this competition.

As I said, we would open the door to even monolithic case-segmented designs, and we would try to get the performance that we think we can get and we need.

Next slide.

In talking a little bit about performance—and in your handout it's out of order. I'm now back one page. Up in your upper right-hand corner it's labeled 9-6 and entitled "Performance Options and Considerations."

On the left-hand, what I have here is a little balance. In other words, performance requirements on the left and options to gain that performance that are open to us on the right. Why would we like to have the performance? Well, first of all, starting at the bottom of the scale, we are experiencing a current and a projected weight growth as a result of the 51-L accident.

Secondly, if the filament wound case program should be terminated, and we have had a number of technical problems, as you know, and we have reported to you in our structural tests in that program, we would like to get that performance back. And later I can talk to you both for KSC or for Vandenberg why that's important to us.

Finally, I personally have a desire that if it is cost-effective to gain the performance back, I would like to run our main engines at a lower thrust. As you know, most of the manifests out of KSC that we presently have requires a 104 percent engines. We could gain about 4000 pounds of performance. We could run every flight out of Kennedy that's presently on our manifest at 100 percent, and if we ever do fly flights at 109 percent and we have this performance, we could run those flights at 104 for which we already have a good data base. So I think there's a big advantage there that I can't quantify on the main engine program because of that.

How will we get the performance? Well, we're doing two things. We are already studying what is called a heads-up launch. That is, to change the profile of the Orbiter so that we lift off the pad and then roll to the down range azimuth, rather than rolling heads-down, we would roll heads-up and climb out of the lower atmosphere at a little steeper—we would probably change the burn traces on the motors to match this performance, and then bend over. And we can gain some performance there.

And we can do that, incidentally. We don't need an advanced solid rocket motor to do that. We are working on that and we have been working on it, and plan to continue. We haven't proven that we can do it, but it's a good option and we want to continue.

The second thing, in studying the advanced solid rocket motor, is that if we are going to go to the trouble to get more modernization, better quality, more reliability in a new motor, the delta cost to get better performance is not large, and we would get that delta essentially in one of two or three ways:

First of all, we could lighten the case by going to a different steel. In other words, lighten the inert weight of the motor. And we think we can do that, whereas when the original motor was

planned, we weren't comfortable because of the industry experience base with this steel. And I can let J.R. Thompson talk to that.

The second major thing is, is that we can change to a different propellant in the motor. And I am not talking about a new development of a propellant that's not in use today. It's a higher performance based propellant, and we presently, in our present motor, don't use it. The combination of these two things, we believe, can gain us about 10,000 pounds, delivered to orbit in performance. So even though it's not a cost-driver, and we could build a new motor without going after it, to me it doesn't make any sense not to. If we are going to build a new motor, we ought to make sure that the last 15 years of our shuttle operation has the proper balance between our up weight capability and our down weight landing capability.

Next slide.

This slide is page 9 in your handout, and it's essentially a schedule over the next few years of taking us back to where the 51-L accident found us, and how we would propose to move out now. Above the—and I won't go through it all, but we're essentially in the middle of fiscal year 1987 reporting this strategy and plan to this committee. About halfway down the page you will notice that what we propose to do over the next year is to spend some money that we have available on Phase B studies to gain that data base that the source evaluation board could use in a program, if we can get it justified both within the Administration and approved by the Congress in FY 1989 budget.

And then move out on the phase C/D Development program. And the total time required, and frankly, I wish we could do it a lot sooner, but to hold a full and open competition, and then qualify a new—quality the winner, and then have him demonstrate through a complete qualification and certification, that process takes about four to four and a half years. Even though this contractor would be on contract for these preceding four or five years, the first flight of the motor would be in FY 1993.

And going back to my original comments, I think that's about the point where we can realistically, from a national point of view, correct the transportation problems that need correcting, so that NASA can move out in whatever direction it wants. We can't do that until the transportation difficulties are overcome. And that's the reason I think that this matches very well the time that we needed.

I only have a couple more viewgraphs. Could I have the next one, please. I'm sorry, that's the one that I just talked to. Could you back up to the previous one.

Now, this is page 10, and I apologize for that. These are the milestones that we think we can meet, and we wanted to provide them to you so that you can track our progress.

We have done the Block 2 studies of last winter, and reported that to this Congress. We have provided to you several weeks ago in letter form and a couple of data packages this acquisition and plan. We are prepared to initiate the phase B effort. And over the next time, leading up to Fiscal 1989 we want to prepare ourselves the start of the proposed program, which would be the phase C and D.

Could I have the final slide.

This is one that I made up last night and it's not in your package. But to me these are the highlights of this program. If you could boil all this down, and it is complicated, to one piece of paper, to me this is what this is all about.

First of all, full and open competition, where we would invite proposals from both major technical varieties, the case segmented and the monolithic, and it would be open to all U.S. competitors.

Secondly, an emphasis on improved quality and safety through automation and through advanced manufacturing methods and the processing of these motors. This would be a tremendous step forward for this industry, whether these motors were used on manned or unmanned vehicles.

Secondly, the performance sets us up, so that the shuttle capability for the years 1993, 1994, and 1995, all the way out to the year 2010, which is about where I think the last shuttle flight is going to be, somewhere out there, is that that whole period we would have available the performance that we can gain from this proposal.

Finally, the subject of a heavy lift vehicle is being debated hotly. I guess you know, it's no secret that we think one of the major competitors would be a shuttle derived heavy lift vehicle. This new motor could be used, we think, without change on that vehicle, and it would provide it also with more capability.

Mr. Chairman, thank you very much for indulging me to go through this proposal. J.R. Thompson and I are happy to take any questions.

[The prepared statement plus answers to questions asked of Admiral Truly follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

Statement of

Richard H. Truly
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I appreciate the opportunity to appear before you to discuss our acquisition strategy and plans for the Shuttle Solid Rocket Motor (SRM). I would like to begin by discussing the background, basis, and rationale for our assessment and strategy.

The SRM development contract awarded to Morton Thiokol in 1974 provided for the design, development, qualification, and initial delivery of 6 flight sets of the SRM. Two major contract modifications for production deliveries have been negotiated: Buy I in 1982 for 9 flight sets and Buy II in 1984 for 23 flight sets. A total of 13 flight sets of the redesigned configuration remain to be delivered to complete the Buy II procurement. A third production increment for 60 flight sets (Buy III) was authorized and under negotiation at the time of the Challenger accident, but negotiations were terminated and further procurement actions placed on hold.

Congress has expressed a strong interest in NASA's acquisition strategy for future

NASA SRM buys. The Urgent Supplemental Appropriation Act of 1986, Public Law 99-349, directed NASA to make sufficient funds available to conduct a study of an alternative solid rocket motor design by December 31, 1986, and to forward the results to the Committees on Appropriation. The Committee directed that, when a final design is selected, a request for proposals for a "second source" be issued, if the agency determines that such an approach can be adopted from within available resources.

Section 108 of the FY 1987 NASA Authorization Act, H.R. 5495, as passed by the Congress, required that we submit a comprehensive acquisition strategy and plan for continued procurement of Space Shuttle solid rocket motors by March 31, 1987.

In September 1986, NASA issued five Block II SRM study contracts to the industry to define alternate designs and planning to support the Space Shuttle requirements. The studies were conducted by Aerojet Strategic Propulsion, Atlantic Research, Hercules, Morton Thiokol, and United Technologies. There were no technical constraints other than the Space Shuttle SRM envelope, performance, and materials criteria. Design concepts, supporting analyses, a recommended development and end item specification, assessment of corporate capabilities, and program cost estimates were products of these studies.

The contractors' design assessments, with emphasis on SRM joint designs, were structured to support the MSFC Redesign Team's critique of the Morton Thiokol design. The Block II study recommendations were evaluated by separate NASA Technical and Resource Teams to determine their technical merit and the impact of their adoption on resources and schedules. The Block II study contracts were completed by December 31, 1986, and a summary report was submitted to Congress on January 16, 1987. The NASA technical assessment of the Block II study recommendations concluded:

- The monolithic design concept could reduce the SRM failure modes and, hence, improve reliability and flight safety. However, the technology necessary for large monolithic SRM's has not been adequately demonstrated.

- Concepts presented could enhance flight safety and reliability and could significantly increase the performance capability of the Space Shuttle.

- The performance improvement could increase payload capabilities by up to 7,200 pounds with the proposed "Heads-Up" trajectory. ("Heads-Up" trajectories are being evaluated separately by the Space Shuttle Program, but would dictate a revised SRM ballistic performance profile.) Additional payload capability could be achieved with a more energetic propellant system to provide a total increase of approximately 10,000 pounds.

In developing an acquisition strategy for the SRM, a number of considerations and objectives were considered important. Major objectives considered were the potential to improve SRM reliability, increase procurement competition, and improve Shuttle performance. The potential to improve performance is important as a result of the weight growth in the STS system resulting from STS 51-L recovery decisions and from the desire to run the Space Shuttle main engine at lower thrust settings. An additional consideration is the potential elimination of the filament wound case program and resulting avoidance of future costs for the incorporation of redesign and requalification of the required SRM design changes now being made in the STS 51-L recovery program.

Three procurement options were examined in connection with the continued production of SRM's. The options considered in developing a course of action were:

Option I - Competition of Redesigned SRM
Option II - Continued Single Source Procurement of the Redesigned SRM
Option III - Competition of Advanced (Upgraded) SRM

OPTION I COMPETITION OF REDESIGNED SOLID ROCKET MOTOR

The SRM design to be produced under Option I would be the redesign configuration with the only additional planned change being the deletion of asbestos material.

Option I requires the prospective contractors to establish facilities for production operations compatible with the current segmented design. These facilities would be comparable in function to those in place at Morton Thiokol and be capable of supporting projected annual flight rates. In the recent Block II studies, two contractors, in addition to Morton Thiokol recommended segmented design concepts. Their facility cost estimates ranged from $80M to $200M. The cost of facilities are

assumed, based on the contractors' statements, to be corporately funded and recovered through amortization as solid rocket motors are produced. In addition to the base cost for Option II, the cost to qualify a second source contractor is estimated to be $160 million. This cost would also have to be funded by NASA as well as the additional cost to monitor two contractors.

OPTION II CONTINUED SINGLE SOURCE PROCUREMENT OF THE REDESIGNED SRM

The redesigned SRM must be demonstrated to be reliable and safe before launches are resumed and a rigorous test and evaluation program has been defined to ensure reliability. The SRM redesign and requalification program includes in-depth oversight by various groups including the National Research Council (NRC) to ensure confidence in future flight operations.

Since the redesigned program will establish a reliable and safe SRM, continuance of the current basic program is considered an option consistent with current budget planning. The program costs, additive to the current contract, would result in a total contract value of $3.8 billion in FY 1987$ for 163 flights through FY 1999 (preliminary estimate.) This period was used as a study baseline and the additional costs are consistent with current budgetary planning. This option would retain SRM production with Morton Thiokol.

OPTION III COMPETITION OF AN ADVANCED (UPGRADED) SOLID ROCKET MOTOR (ASRM)

The NASA Technical Evaluation Team recognized several design changes that could enchance SRM reliability, safety, and performance. Those changes included:

- Monolithic design concept to reduce the number of joints exposed to hot gas and potential leakage failure modes. (Concept demonstration required to support implementation.)

- Nozzle design changes to incorporate advanced ablative materials and increase erosion safety margins. The design changes could also reduce the number of composite sections and joints, stiffen the support structure to enhance bond line strength, improve thermal protection for the gimbal bearing, and reduce nozzle weight for payload improvement.

- Igniter assembly joint and seal redesign to reduce leakage potential.

- Redesign of the motor case to incorporate bolted flange joints to reduce seal surface dynamics and enhance seal reliability. Incorporate a higher strength steel alloy (MAR-T250) to reduce overall SRM weight. Welding capability of the material would permit development of full length casting segments, thus eliminating the factory joints as potential leak sources and further reducing motor weight.

- Insulation material changes to eliminate asbestos filler used in current insulation.

- Propellant change from the current PBAN to a HTPB formulation to increase performance and payload capability.

Additional improvement in SRM reliability is achievable by adoption of modern automated manufacturing plant operations to reduce the potential for human error. These operations include the use of robotics for surface preparation and insulation lay-up, case hardware cleaning and refurbishment, and nozzle manufacture. Automatic guided vehicles and automated measuring equipment can readily improve the transportation and accuracy of material control for propellant formulation, transfer and casting. The reduction of human exposure to hazardous operations has obvious safety advantages as well. Proper adaptation of such automated operations, including central computer plant controls, requires further detailed evaluation to identify SRM facility design requirements and capability.

After careful consideration of the available options, NASA concludes that Option III represents the Agency's preferred long-term alternative by providing the potential for:

- Improved reliability and flight safety.
- Procurement competition.
- Improved flight performance.
- A high technology SRM facility for:
    - Improved quality control.

- Reduced operational hazards.
- Reduced labor cost.
- NASA sponsored technology spin-off.

Neither establishment of a second source for the current redesign (Option I), nor continued reliance only on the present supplier (Option II), will provide the increased performance required.

We believe that this plan is responsive to the intent of Congress and the correct approach for the acquisition of future Shuttle solid rocket motors. We are prepared to proceed with program implementation with a Phase B engineering effort for an ASRM design in fiscal years 1987 and 1988, which could be followed by a Phase C/D effort (design, development, test, and production) beginning in fiscal year 1989. The Phase B effort and other supporting studies will be accomplished within available appropriations for fiscal years 1987 and budgeted amounts for 1988. The Phase C/D contract would not be awarded until fiscal year 1989 and would be dependent on FY 1989 budget decisions. Competition will provide technically superior designs and the most cost effective processes consistent with the required levels of quality and reliability. While development and production costs will depend on the final design selected and the capabilities of the winning contractor, development costs are estimated to be in the range of $450 million.

Mr. Chairman, as you are aware, this has been an especially difficult problem, not only because of the problems associated with the accident and the requirement that we have the best technical answer for ensuring that the solid rocket motors and the Shuttle system are safe and reliable, but also because of the reduced flight rate, the need to ensure that we have an adequate industrial capacity for solid rocket motors in this country, and the budgetary implications of the various options.

I believe that the option which we have selected, to compete an advanced solid rocket motor is the best approach to ensuring that we will have improved reliability and flight safety as well as competition in contracting, an improved industrial base

with improved quality control, and reduced operational hazards. I would like to thank you for the support we have received from you and the members of this Subcommittee. I believe that we have made progress during this last year and that with your help we can return this country to space and reinvigorate this nation's space program.

This concludes my formal testimony. I will be glad to answer any questions you have.

4-21-87
ME-26 -0

*Subcommittee on*
*Space Science and Applications*
*Committee on Science, Space and Technology*
*HOUSE OF REPRESENTATIVES*

# ACQUISITION STRATEGY AND PLAN
# SPACE SHUTTLE
# ADVANCED SOLID ROCKET MOTOR

975

*APRIL 23, 1987*

# AGENDA

- *CONGRESSIONAL DIRECTION*
- *ACQUISITION OPTIONS CONSIDERED*
- *NASA ADVANCED SOLID ROCKET MOTOR ACQUISITION STRATEGY / PLAN*
- *LIQUID ROCKET BOOSTER STUDY*
- *SCHEDULE / COSTS*

# 99th CONGRESS DIRECTION

## CONFERENCE REPORT ACCOMPANYING URGENT SUPPLEMENTAL APPROPRIATIONS ACT, 1986 (Pub. L. 99-349)

3-31-87
ME-26 -10 -3

- *STUDY ALTERNATIVE SRB DESIGN*
  - *-COMPLETE BY 12-31-86*
- *WHEN FINAL DESIGN SELECTED*
  - *-RFP FOR SECOND SOURCE (IF WITHIN AVAILABLE RESOURCES)*
- *MAKE BOOSTER REDESIGN AND REQUALIFICATION DATA AVAILABLE*

## NASA AUTHORIZATION PASSED BY CONGRESS, 1987 (H.R. 5495)

- *SUBMIT SRM ACQUISITION STRATEGY AND PLAN TO CONGRESS BY 3/31/87*
  - *-DECISION ON DESIGN*
  - *-COMPETITION ALTERNATIVES*
  - *-COSTS/BENEFITS OF EACH*
- *BEFORE ISSUING OR EXTENDING MTI CONTRACT:*
  - *-ISSUE RFP FOR SECOND SOURCE*
  - *-NOTIFY CONGRESS OF REQUIRED MTI EXTENSION; WAIT 30 DAYS*
- *DETERMINE FUNDING NECESSARY*
- *CONSIDER NOZZLE / SRM SEPARATELY*
- *ACTIONS CONSISTENT WITH COMPETITION IN CONTRACTING ACT (CICA)*

# BLOCK II SRM STUDY

## ESTABLISHED TO EVALUATE NEW DESIGN CONCEPTS

1-31-87
ME 26-4 4

| | |
|---|---|
| • *PERIOD OF PERFORMANCE* | SEPTEMBER 2 TO DECEMBER 31, 1986 |
| • *CONTRACT TYPE* | FIRM-FIXED-PRICE |
| • *CONTRACT VALUE* | $500K MAX PER CONTRACTOR |
| • *PURPOSE* | UNCONSTRAINED INDEPENDENT DESIGN ANALYSES TO:<br>• SUPPORT REDESIGN TEAM DECISION<br>• SUPPORT NASA'S COMMITMENT TO CONGRESS FOR LONG TERM SRM PROCUREMENT PLANNING |
| • CONTRACTORS | AEROJET STRATEGIC PROPULSION CO.<br>ATLANTIC RESEARCH CORPORATION<br>HERCULES, INC.<br>MORTON-THIOKOL, INC.<br>UNITED TECHNOLOGIES CORPORATION, Chemical Systems Division |
| • *HIGHLIGHTS FROM REPORTS* | MOTOR CONCEPT<br>[3] RECOMMENDED SEGMENTED MOTORS<br>[2] RECOMMENDED MONOLITHIC MOTORS<br>CASE JOINT<br>[1] CONTRACTOR USED BOLTED FLANGE<br>[2] CONTRACTORS USED MODIFIED TANG AND CLEVIS<br>[2] NO FIELD JOINTS (MONOLITHIC)<br>NOZZLE JOINT<br>-ALL RECOMMENDED UPGRADES OF CASE TO NOZZLE JOINT AND NOZZLE |

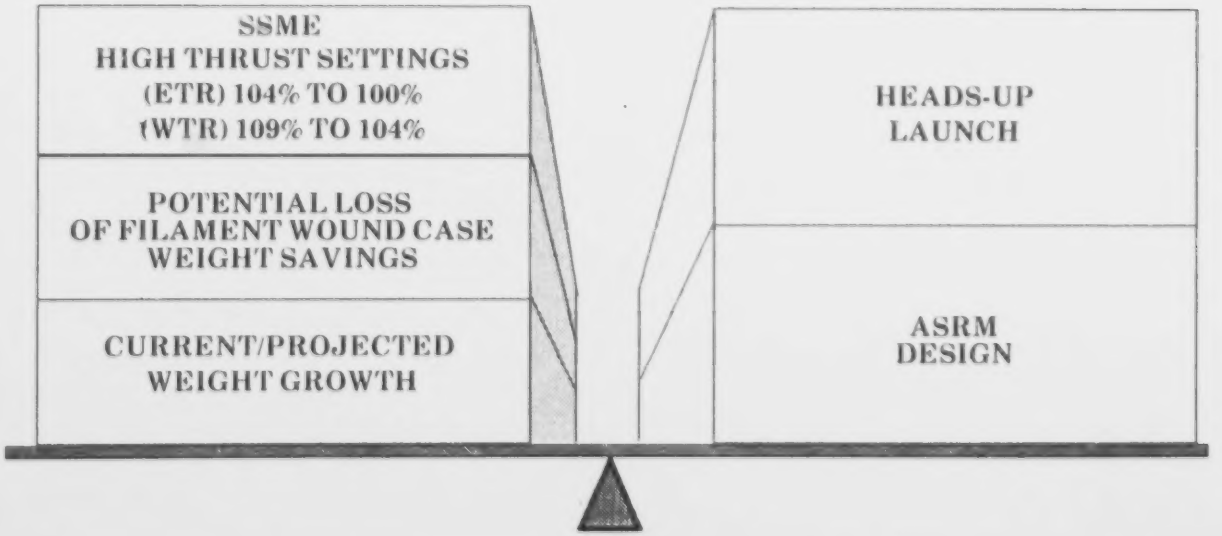
# SRM ACQUISITION OPTIONS CONSIDERED

***OPTION I*** TRUE SECOND PRODUCTION SOURCE OF REDESIGNED SRM

***OPTION II*** NO CHANGE - MTI CONTINUE PRODUCTION OF REDESIGNED SRM INDEFINITELY

***OPTION III*** UPGRADE SRM HARDWARE AND PERFORMANCE WITH OPEN COMPETITION

# ASRM
# PERFORMANCE OPTIONS/CONSIDERATIONS



# Proposed ASRM Acquisition Strategy & Plan

## DEVELOP DATA BASE FOR ADVANCED SOLID ROCKET MOTOR (ASRM) PROG

- *INITIATE PHASE B ENGINEERING -FY'87 AND FY'88 (to include monolithic and segment designs)*
- *INITIATE SYSTEMS PERFORMANCE STUDIES*
- *ESTABLISH ASRM MONOLITHIC AND SEGMENTED DATA BASE FOR FURTHER DECISIONS*

## PREPARE JUSTIFICATION FOR FISCAL YEAR 1989 BUDGET, INCLUDING PLAN FOR POSSIBLE ASRM PHASE C AND D

- *FULL AND OPEN COMPETITION*
- *EMPHASIS ON MODERNIZED FACILITY, IMPROVED PROCESS AND QUALITY CONTROL*
- *CONSIDER PLANT ON FEDERAL PROPERTY*
- *MONOLITHIC OR SEGMENTED DESIGN COULD COMPETE*
- *INCREASED SYSTEM PERFORMANCE*

# STS LIQUID ROCKET BOOSTER STUDY

## OBJECTIVE:

- *ASSESS FEASIBILITY OF REPLACING SOLID ROCKET BOOSTERS*
  - *-PERFORMANCE*
  - *-COST*
  - *-STS INTEGRATION*
  - *-LAUNCH FACILITY INTEGRATION*

- *RETAIN OPTION FOR IMPLEMENTATION*

## STUDY APPROACH:

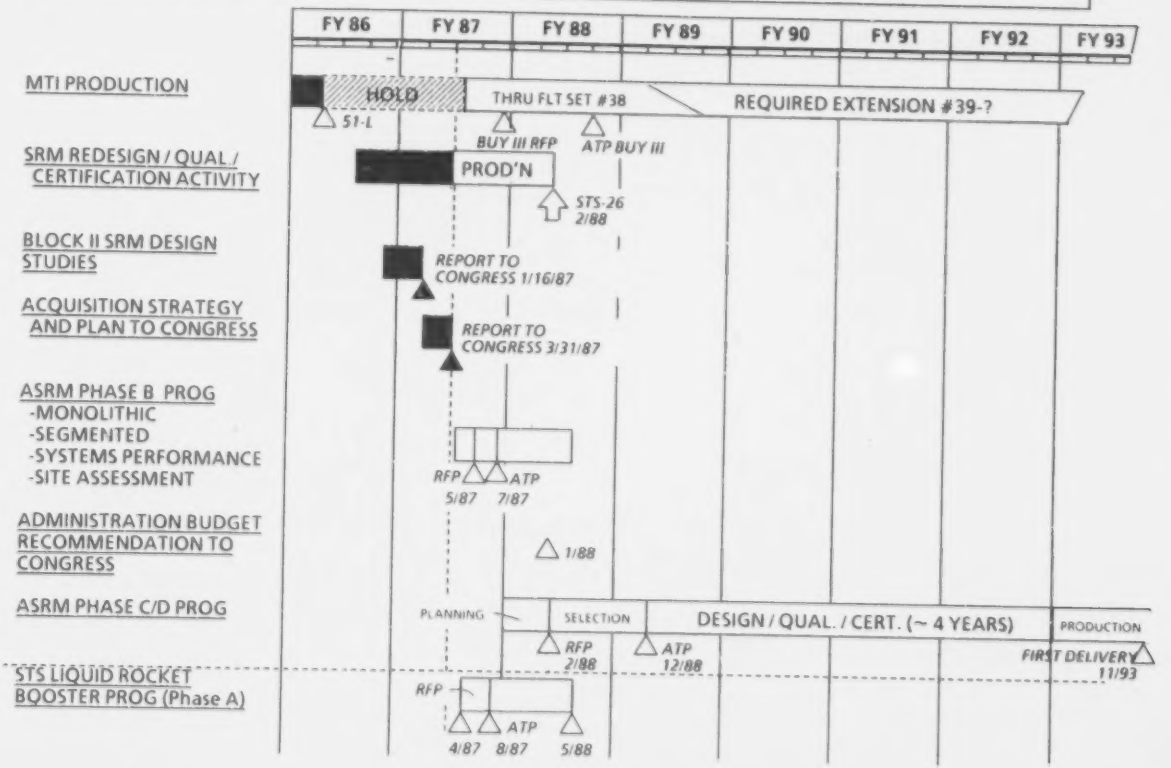
- *ON-GOING IN-HOUSE STUDIES*

- *LIQUID ROCKET BOOSTER PHASE A ($6M)*
  - *-PRESSURE FED AND PUMP FED*
  - *-CONTRACT AWARDS: AUGUST, 1987*
  - *-PERIOD OF PERFORMANCE: 9 MONTHS*

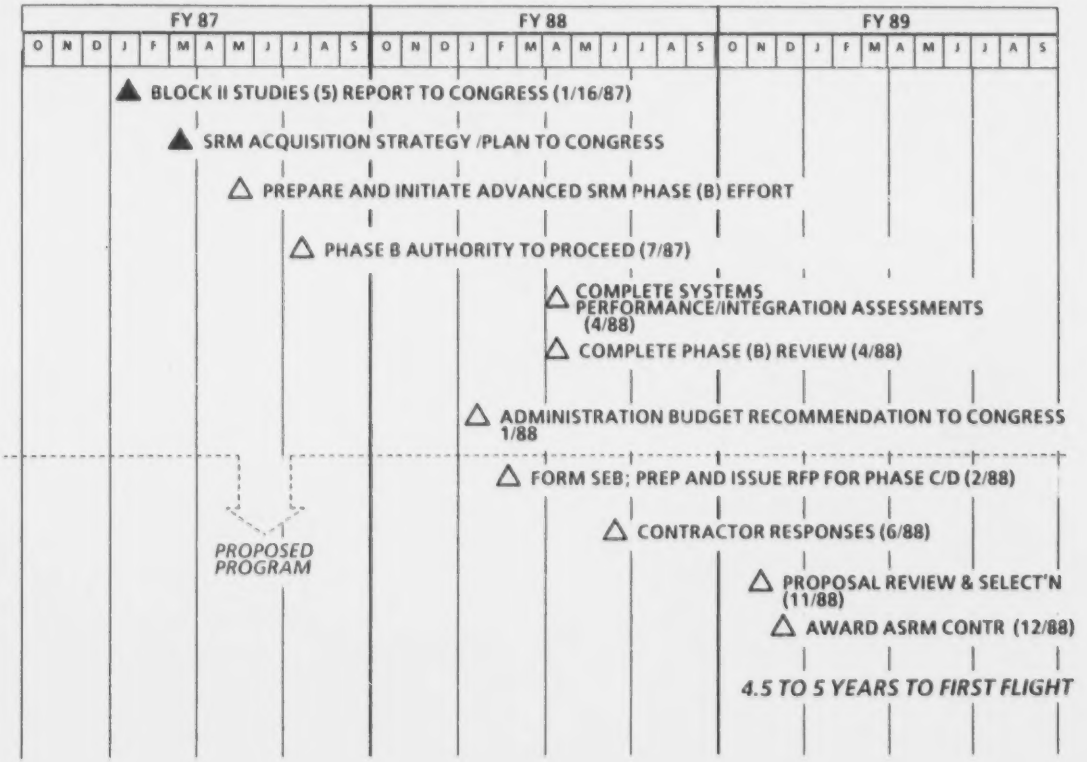
- *SUPPORT ACTIVITIES*
  - *-STS INTEGRATION STUDY ($3M)*
  - *-LAUNCH FACILITY INTEGRATION STUDY ($3M)*
  - *-ADVANCED PROPULSION TECHNOLOGY*

3-24-87 GM
1175-11-9

# PROPOSED SRM ACQUISITION TIME-PHASING



# ADVANCED SRM (ASRM) Schedule Milestones


FY 87
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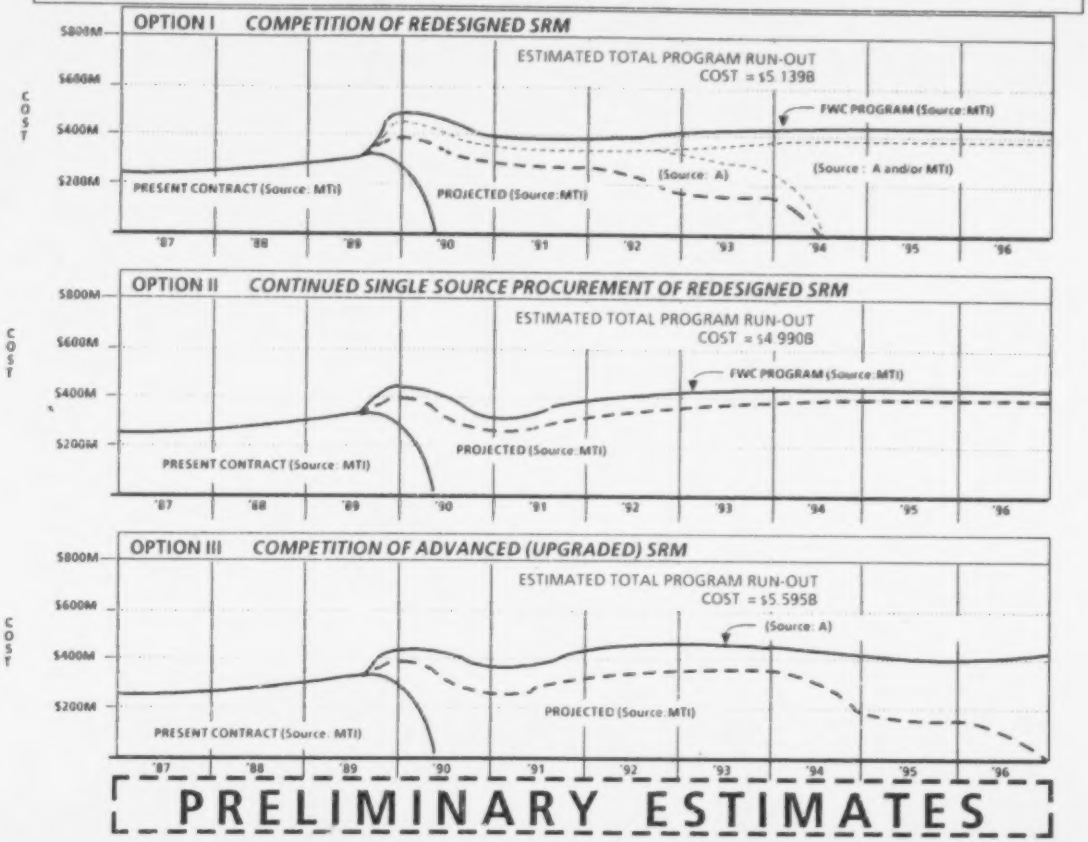
BLOCK II STUDIES (5) REPORT TO CONGRESS (1/16/87)
SRM ACQUISITION STRATEGY /PLAN TO CONGRESS
PREPARE AND INITIATE ADVANCED SRM PHASE (B) EFFORT
PHASE B AUTHORITY TO PROCEED (7/87)
COMPLETE SYSTEMS PERFORMANCE/INTEGRATION ASSESSMENTS (4/88)
COMPLETE PHASE (B) REVIEW (4/88)
ADMINISTRATION BUDGET RECOMMENDATION TO CONGRESS 1/88
FORM SEB; PREP AND ISSUE RFP FOR PHASE C/D (2/88)
CONTRACTOR RESPONSES (6/88)
PROPOSED PROGRAM
PROPOSAL REVIEW & SELECT'N (11/88)
AWARD ASRM CONTR (12/88)
4.5 TO 5 YEARS TO FIRST FLIGHT

# SRM COST OPTIONS




**PRELIMINARY ESTIMATES**

Responses to written questions submitted by Chrm. Nelson resulting from the April 23, 1987, hearing.

QUESTION-1:

Please describe how you chose the particular procurement options that were included within your study?

ANSWER-1:

The three options selected covered the entire spectrum of viable possibilities, i.e.,

- Continue procurement from the current source
- Develop a second source
- Develop a replacement (advanced) SRM

The final selection of the options was determined following a review with the Administrator and Deputy Administrator.

QUESTION-2:

a. You used three criteria in your study (improving reliability, increasing competition, and improving payload performance) to evaluate the relative merits of each procurement option. Please indicate on a scale of 1 to 10 the relative importance of each of these criteria?

b. Why was "cost" not used as an evaluation criteria?

c. How important would you rate cost on the same 1 to 10 scale?

d. Were there any other criteria that you used to evaluate the different procurement options? If yes, what were they, and how would you rate them on a scale of 1 to 10?

ANSWER-2:

a. The criteria were stated as objectives. The evaluation of the merits of the options was not conducted by a scoring or quantification of criteria. All these criteria were viewed as important. Reliability, which translates flight safety, is a requirement.

Performance was considered of major importance. Enhancing reliability through process control and new "state-of-the-art" facilities and process techniques would be a significant consequence of a new facility and was considered of significant importance followed by introduction of competition.

b/c. Cost was a factor in the overall assessment of options. Performance and reliability enhancement were of major importance on a relative basis.

d. Implementation schedules were also considered as secondary objectives.

QUESTION-3:

What do you believe to be the potential advantages of your recommended procurement option? What are its principal disadvantages?

ANSWER-3:

Option III is the preferred option because it provides the following advantages:

- Enhanced reliability and flight safety
- Procurement competition
- Improved flight performance
- a high technology SRM facility for
  - improved quality control
  - reduced operational hazards
  - reduced labor cost
  - NASA sponsored technology spin-off

The disadvantage of Option III is that it will require five years to fully implement. This is longer than the other two options.

QUESTION 4:

In material that you submitted to the Committee earlier this month, you indicated that in addition to a $465 million development program, Option III also includes the construction of a new rocket motor production facility.

a. How closely is this new facility tied to the success of your recommended option?

b. Why is this new facility needed? Can't reliability and safety improvements be made in existing facilities?

c. What would be the programmatic impact if you were not given permission to build this new facility?

ANSWER-4:

a. The new facility is an essential element of the plan in order to achieve an enhancement in SRM reliability. Both the current redesign and the proposed advanced design improve SRM reliability by mechanical design features. However, further improvement in reliability can come from reducing the potential for human error or enhancing process and material repeatability. The SRM industries' composite experience indicates approximately one half of all motor failures result from a process or human workmanship error. The new facility is specifically oriented towards reducing those potential errors.

b. Improvements can always be made in existing plants, however, modifications to such plants would further entrench the contractor and restrict subsequent procurement competition. NASA's goal is to advance the SRM and to establish a means for subsequent procurement competition. As a secondary consideration, modifications to existing plants could entail compromised process implementation due to the existing structures and equipment.

c. The cost estimate included in the plan assumed the new facility would be built by the contractor on Federal property or contractor property, with costs amortized via allowable tax and accounting regulations. In the event that a monolithic design is selected, new facilities would be required to support this design by at least 4 out of 5 contractors involved. Should any new facility effort be prohibited, then Option III would be constrained significantly in both design option and contractor selection.

QUESTION 5:

You have indicated that the Advanced SRM would be safer than the motor that is now being developed by Thiokol.

a. Can you qualify how much safer it will be?

b. If the redesigned motor now being developed by Thiokol is not adequately safe, why would you consider using it?

c. Further, if the redesigned motor is safe enough, why do you need the "advanced motor"?

ANSWER-5:

a. Quantifying a response to this question is difficult at this time. Considerable test data of a specific configuration is required before reliable estimates can be projected.

b. The present redesign is considered to be safe and reliable, however, we will not certify the redesign configuration for flight until full and adequate testing and analyses are completed.

c. The advanced motor is needed to improve reliability, introduce competition and improve Shuttle performance. Improving Shuttle performance is considered of major importance to:

- recover the weight growth from the current 51L recovery program
- to permit elimination of the filament wound case program and avoidance of future redesign costs
- permit the operation of main engines at 100 percent instead of 104 percent (and 104 percent instead of 109 percent) for added margins.

QUESTION-6:

Under Option III, you propose to make some changes to the motor (e.g., use a different propellant, go to a thinner walled but "stronger" case material, etc.) which are intended to improve the lift performance of the motor -- not make it safer.

a. What is the possibility that some of these "performance" changes may in fact introduce unexpected new problems or defects into the flight hardware?

b. If the primary objective of this program is to make a "safer" motor, why not stop there rather than taking the risk of introducing new problems by trying to make "performance improvements" as well?

ANSWER-6:

a. Any design change reduces the data base by definition, therefore the possibility of unexpacted problems is ever present. However, the development and qualification program, coupled with the learning from the redesign program, is expected to ensure such "problems" are identified and resolved prior to the delivery of flight hardware.

b. As stated in the plan, "Option III responds to the need for continually seeking higher SRM reliability and the need to provide more booster performance." Since advancements in both areas are desired for Space Shuttle objectives, they were combined into this one Option.

QUESTION-7:

a. To your knowledge, are there any adverse safety implications to having two independent suppliers of Solid Rocket Motors for the Space Shuttle program?

b. One contractor is claiming that the Challenger accident would probably not have occurred if there had been two competing motor contractors prior to the accident. What do you think of this claim?

ANSWER 7:

a. Dual sources would tend to evolve into a cost reduction competition under current procurement regulations and the industry's incentive nature. Although procurement SRM's would be subject to the same safety and reliability requirements as other NASA shuttle procurements, the competitive environment and need to monitor two separate contractors could have an adverse implication for safety.

b. NASA has no information nor is there any substantive justification that we are aware of for this claim.

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QUESTION-8:

If ultimately you are given permission to do everything that you would like to do under Option III what would be the total investment cost of this option, if you include each of the following:

- o R&D costs;
- o Qualification/certification costs;
- o Construction of a new factory;
- o Purchase of new production "tooling," and
- o Purchase of new flight hardware?

ANSWER-8:

The estimated costs, in FY 1987 dollars, projected for the ASRM program, exclusive of the definition effort, are:

| | |
|---|---|
| Qualification (Design, Development & Test) | $450 million (See Note 1) |
| Construction of new factory | $300-400 million |
| New Hardware | $30 million per set (includes amortization of new facility costs) |

(NOTE 1:) Inclusive of tooling and replacement reuseable hardware based on projections from initial SRM program costs.

These costs projections will be revised as the result of the definition effort which is to be initiated during July 1987.

QUESTION-9:

The cost data that you submitted to the Committee earlier this month indicated that the production cost (subsequent to the R&D and "qualification" phases of the program) for the motor flight sets produced under each option would be roughly as follows:

- o $22.2 million for "optional" single source motors under Option I;
- o $24.6 million for sole source motors from Thiokol under Option II; and
- o $30.0 million for "advanced" motors developed under Option III.

Why is the production cost of the motors produced under Option III so much greater than the production cost for the motors procured under the other two options?

ANSWER-9:

Option III assumed learning curve regression that would occur due to the introduction of a new design and processing facility. The estimate also includes the amortization of the cost of new reuseable hardware and the new facility.

QUESTION-10:

Theoretically, in the presence of a "dual source" competitive environment there are two factors that try to drive costs in opposite direction?

- o competition tries to drive costs down; while
- o production inefficiency tries to drive costs up (because each of the contractors are producing at a reduced rate).

According to the data available to you for the Solid Rocket Motor program, how do these two opposing factors "balance out" for each of the following production rates:

a. 24 flight sets per year?
b. 16 flight sets per year?
c. 12 flight sets per year?

ANSWER-10:

A study was conducted to determine production rate cost effects in support of the 1985 CBD assessment of a split buy. That study was based on an assumed delivery rate of 24 flight sets per year and assessed the effect of delivery rate reductions on unit costs. The conclusions drawn have been supported by other independent projections by industry. Therefore, based on a 24 unit/year model, the production cost relationships are:

16 units (33 1/3 percent rate reduction): + 15 percent cost
12 units (50 percent rate reduction): + 29 percent cost

QUESTION-11:

a. Besides trying to reduce costs, are there any other reasons why it may be a good idea for you to have two sources of supply for Solid Rocket Motors?

b. Are there any other elements of Space Shuttle flight hardware that would benefit from competition for the same reasons?

ANSWER-11:

a. As stated in the Plan, NASA evaluated dual source procurement via a CBD announcement. As a consequence, a decision was announced in December, 1985 that a second source for the SRM was in the national interest for "national security and for broadening the industrial base". That decision included consideration of either a natural or industrial disaster causing production interruption. Dual source procurement also provides an incentive for contractor performance due to the threat of business loss.

b. The manufacturing and related tooling complexities are different for other major elements of the Space Shuttle. In general, their manufacturing operations are less susceptible to industrial disasters. However, NASA has initiated second source

ANSWER-14:

a. The Space Shuttle is designed to handle a mix of payloads not just a single "spacecraft". The cost per mission is essentially constant, therefore, it is cost effective to maximize orbital delivery capabilities of each flight.

b. Some payloads will always require interaction with a manned launch vehicle, however, a number of payloads do not. NASA is considering the use of expendable launch vehicles to minimize launch costs and maximize orbital delivery flexibility.

c. The intent of NASA'S plan was to accommodate increased performance concurrently with design and process changes for reliability enhancement. Should the performance increase planning not be authorized, then Space Shuttle payload capabilities could not be increased. Furthermore, current mission planning requires operating the SSME at 104 percent and (with potential to 109 percent) power levels for specific missions. The higher performance SRM could alleviate these requirements to reduce both the numbers of missions requiring higher SSME operating levels and/or reducing the operating time at those levels.

QUESTION-15:

a. In Option I, you list as an "optional" alternative the holding of a competition between Thiokol and the "second source" to choose a "single source" of supply?

b. Why did you not consider as a separate option simply holding a "winner take all" competition for the production of the redesigned SRM rather than going through the preliminary step of choosing and qualifying a "second source" contractor?

c. What do you think would be the advantages and disadvantages of holding a "winner take all" competition for the production of the redesigned SRM now being developed by Thiokol?

ANSWER-15:

a. Yes, we do list as an "optional" alternative the holding of a competition between Thiokol and the "second source" to choose a "single source" of supply.

b. The conduct of a "winner take all" competition is not recommended until a second source is established for two reasons:

(1) A problem or delay in second source qualification would cause a costly delay of the Space Shuttle program.

(2) The second source competitor would be at a disadvantage without an adequate data base covering the entire program of procurement, manufacturing, NDE, testing, post test (flight) hardware refurbishment, engineering configuration control and flight certification.

procurement of SSME turbopumps, in part, due to a need to maintain a broader industrial base of liquid propulsion technology.

QUESTION-12:

Legally, would it be possible for NASA to hold a "second source" competition in order to obtain firm information to determine if this procurement philosophy would save the government money on the Shuttle program--and then cancel the procurement if it is found that second sourcing would cost more than it would save?

ANSWER-12:

The Federal Acquisition Regulation (FAR) Subpart 15.405(c) states in part, "except for solicitations for information or planning purposes, contracting officers shall solicit proposals or quotations only when there is a definite intention to award a contract." Concerning solicitations for information or planning purposes, such solicitations cannot be used as a basis for awarding a contract. Thus, a second source competition solicitation for the purpose stated in the question would be contrary to the FAR which has the force and effect of law.

QUESTION-13:

How much of an increase in overall payload lift capability would the Advanced SRM give the Space Shuttle compared to the redesigned SRM now being developed by Thiokol?

ANSWER-13:

The ASRM is projected to increase payload capability by up to 10,000 pounds against the STS 51-L design baseline and up to about 12,000 pounds over the current redesigned SRM now being developed by Morton Thiokol.

QUESTION-14:

a. According to your schedule the Advanced Solid Rocket Motor that you propose to develop would not be available in any signficant number before the mid 1990's. Since most of the new spacecraft that will be launched during that period have not yet been designed, shouldn't it be possible for the designers of those future spacecraft to accommodate to what ever the Shuttle lift capability is as long as they know what the numbers are before they begin their design process?

b. When payloads are found to be too heavy for the Space Shuttle, shouldn't it normally be possible to move those payloads to expendable launch vehicles?

c. What do you think would be the overall impact on the U.S. space program if you did not make the proposed improvements in the performance of the Solid Rocket Motor?

ANSWER-14:

a. The Space Shuttle is designed to handle a mix of payloads not just a single "spacecraft". The cost per mission is essentially constant, therefore, it is cost effective to maximize orbital delivery capabilities of each flight.

b. Some payloads will always require interaction with a manned launch vehicle; however, a number of payloads do not. NASA is considering the use of expendable launch vehicles to minimize launch costs and maximize orbital delivery flexibility.

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c. Option I was intended to compete the "redesigned SRM" as stated in the Plan. The advantages are potential cost reduction and the principal disadvantage is the potential of unforeseen problems due to reduced production experience.

QUESTION-16:

What do you think would be the advantages and disadvantages of combining options I and III -- i.e., choosing a "second source" supplier while at the same time developing the Advanced SRM?

ANSWER-16:

The advantages would be a combination of:

Option I: Intrinsic effects of contractor motivation and protection against program interruption due to an industrial accident or natural disaster.

Option III: Enhanced reliability and flight safety coupled with increased payload delivery capability.

The disadvantages would be:

Dramatic budget increase requirements to support both Options. The projected unit cost reductions of Option I would probably not be incurred as the single source recompetition would not be viable with the Option III advanced motor delivery initiation within one year. Achievement of the enhanced reliability offered by the ASRM would make obsolete the existing "redesign" configuration. Also, a combination of Option I and III could create a situation where NASA would potentially be managing three different contractors at one time: MTI, the 2nd source contractor and the ASRM contractor.

Last October, the National Research Council recommended that NASA begin to draw up a contingency design for the SRM that could be used if the current redesign being developed by Thiokol is found to be deficient. Option III does comply with the desires of the NRC, however, it goes a step further by "enhancing" the motor as well as "fixing" it.

QUESTION-17:

a. Would you be willing to modify your Option III plans, in order to have the "Phase B" contractors work on two designs in parallel:

- one that would both "fix" the problems with the SRM and "enhance" its performance (as you have proposed in your report); and

- one that would merely "fix" the design"?

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- one that would merely "fix" the design"?

b. What would be the disadvantages of this approach?

ANSWER-17:

a. The advanced solid rocket motor (ASRM) addressed by Option III would enhance reliability by the implementation of automated processes to increase production repeatability and to reduce the potential for human error. The ASRM would also incorporate design improvements responsive to the identified technical issues and increase payload delivery capability. The current Phase B plan includes design studies of both monolithic and segmented SRM designs.

The current redesign SRM program at MTI is expected to provide a safe and reliable SRM. The addition of a third development program addressing only the mechanical redesigns is not considered necessary and would cause considerable drain on resources available to NASA.

b. The principal disadvantage would be the increased time and cost for enlarging the Option III program. The increases would undoubtedly result from an overtaxed management and technical work force to fully implement three parallel programs; the condition would be more severe than the issue raised by Question 18.

QUESTION-18:

If you pursue any of these options at this time, what is the likelihood that the attention of key personnel at Thiokol and the Marshall Space Flight Center would be diverted away from the redesign that they are currently working on?

ANSWER-18:

The requirements to maintain critical skilled personnel at MTI and MSFC devoted to the redesign effort has been recognized. However, the planned Phase B will not require a significant increase in personnel above that utilized for the Block II studies. MTI has a separate advanced planning and proposal group that supported Block II without affecting the mainstream redesign effort. The significant impact to personnel allocations would occur at the release of an RFP for Phase C/D. That release is now scheduled for early 1988 and the redesign effort will have progressed beyond the design phase and will be completing final certification testing. Therefore, both MSFC and MTI should be able to support both Phase B and the redesign program without undue strain.

QUESTION-19:

If NASA eventually does pursue a second source competition for the redesigned motor, do you think that it would be better to hold this competition soon, or to wait until the redesign has been proven safe (possibly after the completion of several flights) and the Agency has developed a better handle on what future Space Shuttle launch rates are likely to be? Why?

ANSWER-19:

The implementation of Option II, if so directed, could either proceed after full confirmation of design adequacy or in parallel. The former would provide a cleaner approach to procurement as the design base would be stable. Such a plan would delay the competition until at least FY 1989. However, NASA does not recommend implementation of Option II as it does not address the long term issues of reliability enhancement or performance requirements.

Mr. NELSON. Let me ask you a question about the timing. If you were to pursue the course that you're talking about, what is the possibility that you're concerned key people at Marshall are going to be drained off into looking into this block 2 motor, at a time at which they and the contractor Thiokol should be concentrating on the redesign of the existing SRB?

Mr. THOMPSON. Let me address that, Mr. Chairman. Obviously, it's something we paid attention to, because this is our proposed plan. I believe we can do it. We're already starting today, just in the processing of our current motor with Thiokol. We're very substantially beefing up our attention to the processing and the inspections. And we would carry that over into the phase B activity.

I don't see how we can back off of it at all, and I think we've got the people to do it. And we've got the people that appreciate the absolute need to do it. Whether we stay with Thiokol or Current Motor through second source or move out in the proposed direction, we have got to increase our attention by an order of magnitude to the process control and the in-process inspection to get the reliability of these motors right up to as close to 100 percent as we can make them. But we've got the resources, to answer your question directly, at Marshall to do that and support it.

Mr. NELSON. Now, do you consider that this proposal, Admiral Truly, is responsive to the National Research Council's recommendation last fall that they want you to come up with a contingency plan, so that if this redesign of the SRB, Lord forbid, should not work, that you've got something else on the burner that you're working on? Is this in part a response to that NRC recommendation?

Admiral TRULY. Let me, first of all, tell you that if I had any doubt that our redesign was not going to work, we would be working on some other redesign. But in response to NRC's insistence that we look at alternatives, I think that we are answering that in the nearer term, alternatives that the program and the Marshall Space Flight Center are looking at that are closer in than this. For example, we're looking at two different methods of insulating the joint between the case segments. We're moving out with, you know, with the long lead acquisition of billets that have more metal on them, so that if in the test program we run into a problem we can attack that quicker.

But in the long-term, this very much answers it, because in this proposal we have the time, to make sure the redesign works. We have the time to look at a higher quality motor that would be easier to maintain.

And so in the long-term, I think this answers their mail better than they had hoped we would do it, frankly.

Mr. NELSON. We've had some concern expressed on our professional staff about going to a different mix of fuel, and that that injects a whole new unknown on this increased performance, SRB. Do you want to comment on that?

Mr. THOMPSON. Well, let me just comment to that. Obviously, we're looking at it. At the time we selected the P-ban propellant, the database on this newer mix was not very substantial. I think that database in the whole Solid Rocket Motor industry has become more comfortable with that since then; and we want to fold

that into this evaluation. But under no circumstances are we going to do anything in this advanced Solid Rocket Motor that would decrease our margins including a change of propellant.

The kind of change we're talking about is nothing substantial at all, but in any event, we've got to have an adequate database to be just as comfortable with any new mix we've got, just say, compared to what we've got today. We are not going after performance at the sacrifice of safety margin, and our real objective in my opinion, is better process control.

Today, we've just got more data to consider other propellants than we had 10, 12, 14 years ago when we made this selection. And I think the industry in general would encourage us to take that look.

Mr. NELSON. So, the essence, if I can—see if I can summarize here what you've said is that, that you think that this proposal is the way to go because we're looking at the shuttle being the manned access to space, well into the next century, until some other kind of manned vehicle is developed. And that being the case, you want to use more recent data, up to date technology in order to get greater safety and increased performance. Is that a fair summary?

Admiral TRULY. I think that is a fair summary.

Mr. NELSON. But you can't get it ready until the middle '90s.

Admiral TRULY. That is true. And as I said earlier, I wish it could be done quicker. It hasn't been delayed by us. As a matter of fact, I personally put a lot of hours with Marshall in looking at all of the various options and pulling them back in time. But I have felt that, if we're going to go to this trouble, and the nation is going to go to this expense, and it is going to be an expense, we ought to get the capability as soon as we can. And the schedule that we think we're on is what it turns out to be on a rational and business like basis.

Mr. NELSON. Let me ask you about a liquid propulsion. Early in the '70s when the shuttle was being designed, one of the attractive options was strap on liquids. Indeed, we understand that the Soviet shuttle has liquid propulsion in addition to its main engines.

Why don't you, if we're going to a totally new redesigned motor, why are you picking the solids as opposed to looking to a liquid in the future?

Admiral TRULY. I didn't mention it because I didn't go through every viewgraph in the package that we presented to you. But we are going to set about during this next year. We do think it's prudent to set about that during this next year in parallel with this phase B, A so-called phase A study of what it would take to build and produce a liquid booster system that could potentially replace the Solid Rocket Motors.

In parallel with that phase A study, that's a conceptual design study, we're also going to turn on some in-house NASA work between the Johnson Space Center and the Marshall Space Flight Center to look at—because the liquid system would be a significantly different aerodynamic design, we would have to essentially requalify the entire ascent phase of the shuttle system. We're not going to spend a great deal of money on this, but we do think these phase A studies are worth doing and should be done.

I will give you my personal opinion, that it is unlikely that the costs associated with totally revamping the shuttle ascent profile including wing loading, tail loading, dynamic pressure, shaping of the orbiter and external tank, and these new liquid motors, I think it is unlikely that that is going to be competitive.

I believe that we are going to be flying with Solid Rocket Motors for a long time. And that's the reason that my gut tells me that probably the place to really move out and position ourselves for a new program, if we can get it authorized, is in the solids. But before the Source Selection Board would be convened for this we should have these phase A studies and we should be able to come back to you after they're completed and report to you, not my personal opinion, but the facts based on the phase A study.

Mr. NELSON. All right. Let me ask you one more question and then I want to turn it over to our members. See if you can give us the benefit of your reasoning and coming to your concusion that as you look to this block 2 motor, you're basically trying to do two things. You're trying to get a system that will take us into the next century, that gives you all the fixes that you need, and it also gives you increased performance. And you have outlined for us today that that will take until 1995. All right.

Give us your reasoning of why not in parallel once you select these contractors to do designs on this, that you would not like them in parallel to be looking just at the fix question without the increased performance as a means for satisfying what we need, and as a possibility of having it available to us much earlier than 1995. Can you speak to that question?

Mr. THOMPSON. Well, let me just address it. Here we do have the contractors that participated in the phase A studies working with us, and it varies by contractor. But over the last several months I formed a Board with the Chief Executive Officer of each of those contractors and several of their chief engineers to get involved with me in our test progress, as we come up on our qualification firings, to get their input into that, so I bring to our program their experience.

I'm confident that the way we're going we can pull it off and do it safely. I want their input. I do not think, from what I know now, there's merit to paralleling that with another effort that doesn't take this big step that Dick is talking about, because I agree with him, we're going to be flying this shuttle system for some probably 20 plus years. And that's a lot of motors. It's about 500 motors.

I believe we can keep our very focused eye on these motors that we've got to produce of today's design, and I'm talking about the redesign, with this input from the rest of input from the rest of industry for 40 or 50 flights which will take up through the mid 1990s. But beyond that, I think we've just got to upgrade these facilities and the way we build them. You look at 4 to 500 motors, and you look back at what people have built in motors in terms of reliability over the last 20 years, and you now extrapolate that, and we know what it costs in terms of life as well as money to lose an orbiter. And I don't like those reliability numbers. So, we've got to do something about it. And I think that the plan that Dick has talked about is that plan.

I wish we could do it faster. We can't. To bring more people on board to do more of what we're doing now, to me is not the answer. It's to try to make substantial improvements in the way the whole industry builds these motors.

It is not up to the technology that we build, say, the external tank. It's just apples and oranges. And I would say the same thing for the space shuttle main engine. And that space shuttle main engine and these Solid Rocket Motors, in my judgment, the chances are very high, whenever we have a problem like we've just had, it's going to rest in one of those two areas. And to me, I don't see how you can afford to do less than we're proposing.

Mr. NELSON. All right. I want you to know that I think you, from this member's standpoint, I think you have made a very good case. We have had some discussion here on the committee about whether or not this is the right way to approach it. I think you have laid out your arguments very succinctly, very directly. And I am inclined to agree with you about the block 2.

Now we come to a more controversial issue, and we'll continue to discuss this whole thing, but we come to a more controversial issue of which I want to defer to the gentleman from New Jersey about the issue of, okay, now we've got the SRB now, the joint of which failed. We're redesigning it, and it's got to take us, in the redesign, of which Admiral Truly, you have indicated that you are absolutely confident in the redesign, that it is going to work and take us until such time as you would have another solid rocket motor of a different breed of cat.

So the question is, as we make sure that we've got these SRBs between now and 1995—I assume this is the plan that we're working on—should you do it with just the existing contractor, or should you do it with a second source or a new competition?

Now let me just lay that out and now turn to the gentleman from New Jersey.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Let me just suggest, Admiral, in all candor that I received these recommendations with real regret, because it was not Congressional intent that we have competition in the program in the next century or late in the next decade, but that we needed competition as soon as practically possible, and for a variety of reasons.

Cost, of course, because other contractors have stated and are prepared to demonstrate that for less money and substantially less time than you are stating, they are prepared to enter into competition.

But beyond cost, the matter of safety, and that it is clearly the intent, the belief of members of this committee and a majority of members on the floor, that the only guarantee for real safety is competition in this program that would result in upgrading the very facilities that Mr. Thompson mentioned.

And now a new factor. Last year when we debated this amendment for second-sourcing, we were talking about the need for guaranteed access to space because of problems of a loss of facilities from a single contractor or personnel problems or corporate difficulties. Now you have that same contractor under legal investigation, facing the possibility of being eliminated or jeopardized in dealing with the Federal Government.

And yet you are proposing that for the next eight years, we remain solely reliant on that one contractor. I think that is bad in safety; it is bad in cost-effectiveness. It is bad in national security and in access to space.

I approached this last year with every intention of being reasonable. I defer whenever I think it's in the best judgments of the program to your own expertise and have tried to be reasonable in drafting an amendment.

This is not a compromise. It is not even an attempt at a compromise. The cost resulting from your plan in dealing exclusively with Morton Thiokol through the mid-1990s are resultingly substantially higher costs, with no real belief, if you share my philosophy that only competition will result in real safety and technical improvements, any reason to believe that we're going to have any greater degree of reliability on these solid rocket motors than we had in the past.

And so I guess while I am pleased to see that we are in the new block going to have a competition, I guess we are headed for a confrontation in the near term and frankly don't see another way to avoid it, but I would, Mr. Chairman, if I could at this point, I'd like to ask a couple of questions, because I'm prepared to be told and have it demonstrated that I'm wrong.

What, Admiral, do you see as the per-unit cost when the shuttle begins to fly again through 1995 of solid rocket motors under the plan that you've outlined?

Mr. THOMPSON. I think if you look at the fair cost and fold in the wrap-around cost, as well as the refurbishment, everything we've got to do on an SRB, it's about $25 million. That's a rough number. And pre-51L, as I recall the numbers, that same number would be in the high teens, about 18, 19, somewhere in there. And if I look back at the things that we're doing—number one, the rate is going down, so that doesn't help the cost per unit. That, of course, would be true for any design. But we are taking some very specific steps to make improvements, and they're not going to be cheap.

Mr. TORRICELLI. Do you just, when other contractors claim that they're prepared under the old design, to make them for $12 or $13 million, and presumably they'd have the same cost of increase as the sole contractor, so you'd be adding another $7 million onto theirs, that results in a $5 or $6 million difference per flight in cost between what other contractors claim they could achieve and what you are contracting for—do you simply just not believe these other contractors?

Mr. THOMPSON. No, no. Well, I haven't talked to any specific contractor on that since I've been back, of course. The $12 to $13 million is our current cost for that motor, if you just want to look at one motor. I'm folding in what I believe are the true costs of wrap-around as well as all the motors you've got in process and the retrieval operation and the cleaning them up so you can then reuse them, and that almost doubles that cost.

Mr. TORRICELLI. Are we talking about a qualifying cost for a second source of $160 million? Is that the figure that you've agreed upon?

Mr. THOMPSON. Yes. I think that if you embark on the path of qualifying another guy to build the same design we've got, so he

doesn't have to talk about the engineering, only the tooling for his facility, somewhere between $160 and $200 million would be my estimate of what it would take to qualify——

Mr. TORRICELLI. So let's see if we at least agree, then, on the basic facts, is that contractors, other contractors, are claiming that they could have a savings of $5 or $6 million per flight, if there were a competition. It would take $160 million to qualify a second source. And how many flights at this point are you anticipating between when flights start again and 1995?

Mr. THOMPSON. I believe we can do this, have it in the air by the end of 1993. And we're talking about—you know, anybody guesses on the rate—but what we're planning now would be about somewhere between 40 and 50 flights, double that for the number of motors.

Mr. TORRICELLI. So, in fact, you would have a full recovery of the second source qualifying costs in relatively few years, if these numbers are accurate.

Mr. THOMPSON. You an look at it that way. To me, I'm not—here cost is very important, here the unit costs. So certainly I'm sensitive to that. But my real objective——

Mr. TORRICELLI. We agree on the numbers. So I don't want to make this my analysis; I want to make it our analysis.

Mr. THOMPSON. The numbers being that——

Mr. TORRICELLI. Well, if you accept the fact that other contractors are saying that they could do this for $5 or $6 million less a flight, and there's $160 million qualifying cost, and we're talking about 50 sets of rocket motors, then in any basic math, the full recovery cost of the second source can be achieved in a few years of flights.

Mr. THOMPSON. The number of flights is a true number.

Mr. TORRICELLI. Well, do we agree that the $6 million was a real number?

Mr. THOMPSON. I'd like to see that so it's based on the same comparison. That includes all the wrap-around costs, as well as all of the refurbishments. I don't know that that's a good number. Let me just take your number. I have not talked to a contractor about this.

Mr. TORRICELLI. Well, maybe we can end this part of the discussion this way. That's my analysis. Those are my numbers. That's my bottom line.

What's yours?

Mr. THOMPSON. My bottom line is, by 1993, earlier if I could do it—I think it's going to take there—I want to build these solid rocket motors a lot better than anybody is building them today. And three guys, building them the same way we're doing them today, whether it's a little more expensive or a little cheaper, to me, is not the shuttle program that this country needs over the next two decades. We are going to have another Challenger on our hands, if we really don't step up over the long haul and put the quality control and the process control in these solid rocket motors. It is not in today's industry.

Mr. TORRICELLI. Sir, I couldn't agree with you more. But we are left with the reality that between now and 1995, 450 Americans riding on $1.5 billion worth of solid rocket motors and untold bil-

lions of dollars worth of hardware belonging to this Government are going to fly into space. And they are doing so again on solid rocket motors built by a single source at an extremely high and increasing cost, with no real reason to believe they're going to be more reliable than the motors that failed before, because it's coming out of the same process.

This is not faulting a single corporation. I do not fault—I'm not saying that they are not capable of doing it. It is my belief that any one contractor with a billion and a half dollar contract does not have sufficient incentive to maintain the proper production facilities or personnel or safety assurances for that long a period of time.

Mr. THOMPSON. We will have a safer motor, or we won't fly. We've got a ground test program, I believe, to demonstrate that, and I do intend to involve all of the other contractors in the evaluation of those tests, as I have indicated.

And, Mr. Congressman, I'm not arguing with you. I would rather devote the resources of the industry, the other teams, on stepping up to what we've really got to do over the long haul and get them to work on that right away. And that is the heart of our proposal.

Admiral TRULY. Mr. Torricelli, could I interject one thing?

Mr. TORRICELLI. Please.

Admiral TRULY. Before I arrived on the scene in 1984, we did a study strictly on cost. Forget for a moment, put aside the argument on quality, reliability, performance, just talking cost.

The economics of a second source—and I'd be pleased to provide that to this committee, if that would be helpful—but I'm told that in that study, at 24 flights per year, it was not cost-effective on the economics of it—it was not cost-effective to split the production and go to a true second source.

We are now talking about, if you believe my present belief in the system, 14 to 16 flights per year; if you believe others, a dozen flights per year, and those non-economical factors are escalating as the production rate decreases.

Mr. TORRICELLI. Admiral, I understand your analysis, and I've listened to it for a period of time and have respected your conclusions. The problem is that I keep looking for different facts, and the only facts that seem to be on the table is that when this committee first started looking at second sourcing, the price of solid rocket motors that was being suggested declined. It's been the only decline.

Now that we're back to talking about a single source, they are escalating. And corporations tell me that they are prepared to walk into your office and sign a contract under the old design, a $13 million set, and contrary to the four and a half year estimates you're citing, say that they can get you a solid rocket motor on that existing design in a little over two years. Now those are their facts.

If their facts are wrong, I'd like to see our facts. But I see their facts and their conclusions against just your conclusions, and it isn't persuasive.

Let me finally, Mr. Chairman—I don't want to take my colleagues' time—and ask, if I could, that I've been told that a notification of intention memo was sent by Royce Mitchell to Ray Woods stating an intention to contract Morton Thiokol to build an alter-

nate redesign segment and to have at least one test fire motor, meaning that in this interim period yet another contract, single source contract, is being discussed.

Do you have any knowledge of that?

Mr. THOMPSON. Let me answer that. I have not seen the memo, but let me tell you what we are doing. We're doing it at the insistence of the folks here at Marshall, as well as Dick Truly and the NRC. We're not putting all our eggs in one basket. I've got a lot of confidence in the path we're on relative to this insulation and seal design, and the details of that, I believe you're probably familiar with, where we have the bond line and the additional O-ring that we've added, as well as the interference fit with the metal parts.

There has been some debate—this goes back six, seven months ago—as to whether a so-called vented design would be better. So we embarked on both in parallel, working with the NRC. It became clear to me that we couldn't juggle all those balls at one time. We had to make a decision and start working to a flight schedule. And we picked our current baseline design.

We're at the point now where we're—and we had carried those other alternates along, working the paper, the analysis, but not to the same flight schedule. We are beefing that activity up. I think it's a wise thing to do. I don't read into that any less confidence myself; it's just a prudent action to take. It's a fairly small modification to the tooling, to get away from the bond line to the vented configuration. So that's an alternate. I don't know whether Royce's memo was talking about that or not, but I am putting some heat on to press that activity up.

And then as well, the new billets that we have to buy, I want enough meat in them, so that if we have to make any further modifications downstream, which I don't expect, in the way we make this clevis, I want to have the latitude in the billet itself to do that.

Over and above that, we are not initiating any equivalent to this at all in terms of our proposal with Morton Thiokol. The activity we've got at Morton Thiokol is to bring on line and qualify the baseline design, and then to hedge a bet in the event we have problems with this bond line in things like this vented joint, which is a fairly minor modification to all existing hardware we've got.

And then I want, in the new billets we buy, to be able to have some more meat on them so we can do something with them.

I've got a concern about this, and that is, Thiokol right now is up to their neck making a baseline work, and that's why I backed off of these alternates early on. I do think we're getting the engineering to the point—and I've encouraged Thiokol and their competitors to get in there and help, that we can take a harder look at this tooling modification, so we've got the flexibility of this so-called vented design and joint in the event we——

Mr. TORRICELLI. No one is suggesting that you shouldn't be looking at alternatives. I think my question is more focused. It is whether in looking at these alternatives, as I understand it from this memorandum, we are again looking exclusively at a single contractor for the concept and design.

Mr. THOMPSON. To be perfectly honest, the modifications we would make are small enough, to me it would be inefficient to get another contractor all cranked up, just to do that. I have encour-

aged Thiokol, as I've indicated, to go out and use these people where they can, the other people, particularly those that are in that area.

And my real intent is to get the rest of the industry to participate with us in this advanced solid rocket motor, which to me is a real challenge, and where they can really contribute, and I hope to the man that they believe that this is the right approach for the total program, and I think it would be a shame if they think that the real job we've got to do is to improve the processing and the way we make these motors, and not just make additional copies of what we've got, and even if it's a little cheaper. I haven't seen——

Mr. TORRICELLI. I certainly agree with that conclusion. And, Mr. Chairman, I'll just conclude on this.

When we gathered after those days after the loss of the shuttle in some very difficult sessions, I think we all walked out with the same intention, and that is that the best and the brightest minds in this country were going to be put to work on assuring American access to space in the decades ahead, wherever they were from and whatever state and whatever corporation, whoever they were; they were going to have a role.

Whether it would appear to me in the smallest of redesign efforts that we've just discussed in this memorandum or for the next 50 flights, carrying this country into another decade, that has not been realized. America is not participating in continuing the space program.

I know how deeply you all feel about this program, and I know you feel more deeply than any of us can about the loss that was suffered. But I will tell you with all sincerity, I believe we are making a profound mistake.

It was not enough to go back and rewrite old contracts and adjust the numbers. We needed to start over. You cited that today yourself. The production facilities are not adequate. There is a need to continue to redefine the technology. We didn't start over, and that is why I think you will see in the coming weeks and months, there is going to be an effort.

I'm prepared to be told I'm wrong with these numbers. If there's not a savings in money, if there is not safety to be achieved, if there's not a reliability, a national security aspect, convince us that we're wrong. But I will tell you frankly, you haven't done so so far.

And so it would appear to me that the numbers that have been demonstrated and the arguments that have been presented, there is still a real case to be made for second-sourcing in the next 24 or 36 months to get the costs down and the reliability up.

I thank you for hearing my comments today, and thank you, Mr. Chairman, for giving me so much time.

Mr. NELSON. To put this in the appropriate context, we have you responding to what was inserted in the NASA authorization bill, and thus, you have come forth with your acquisition strategy and plan for the SRM's. Now, we have basically two components that you have presented to us of your plan.

The second component is a Block II, a redesign and more powerful SRM. There hasn't been a lot of controversy here discussed thus far with regard to that part of your plan. The more controversial is the first part, how do you treat it, the present redesign of the

present SRB, between now until your Block II motors are ready to come on line.

Mr. Torricelli has a certain set of figures. You have presented others. Admiral Truly, you made reference to a study and we would like you to send a copy of that study to us.

[Information to be furnished follows:]

[See charts from April 28, 1987 briefing.]

Mr. NELSON. Over the coming weeks, as we are ready for mark-up, because this is going to be an issue in the mark-up in the NASA authorization bill, we need to simply nail down some of these specific figures so we can try to make some judgments on accurate information.

Admiral TRULY. I'd be pleased to do that right away.

Mr. NELSON. Mr. Packard.

Mr. PACKARD. I had not intended to get involved with the short term question although I think I must ask some questions regarding it. I'm not sure I'm in total agreement with the gentleman from New Jersey.

If we called for a second sourcing on the short term, simply to second source the existing or the modified rocket motors that we will use in our next flight or next 3 or 4 years of flight, 4 or 5 years of flight, perhaps longer, how long would it take for that second sourcing process to actually be in construction?

Mr. THOMPSON. I think it's going to take—probably we could be flying—you know, you have to qualify, although the redesign would have been qualified, but you have to qualify his process. It would be my judgment that you could be flying with a true second source in probably 1991, so you are talking about 2 years. He has to go through a ground test program and qualify his process, so you are talking about a 2 year difference. You are only talking about 2, 3 years at the most, where you would have use of the second source.

In that other short term period, our existing contractor would have to be used, either that or we shut the program down until the second source is ready to produce, or their production lines are functioning. That, of course, we are not willing to do. It certainly would not be your recommendation to shut down until we have a second source.

Admiral TRULY. Absolutely not.

Mr. PACKARD. Let me get to your Option III. In your proposal, you have recommended half a billion dollars for the new design. You are recommending about one-third of a billion dollars for new facilities. How essential are the new facilities? Existing facilities, could they be used and adapted to it? What is the driving reason for your proposal for new facilities?

Admiral TRULY. Mr. Packard, let me first say and I want you to hear from Mr. J.R. Thompson, because he believes very strongly that is a good idea. However, we are not committed in this proposal to that facility. That's one of the reasons we want to spend this next year doing a Phase B study and evaluating that.

We do propose to invite the contractors to consider building a plant on Federal property, so let me just tell you that is not a firm part of what we would do but it is a firm part of what we would look at and I think Mr. Thompson can describe the benefits of that very well.

Mr. THOMPSON. I believe I am together with Dick on this. When I say new facilities, I believe they are required in any event. That doesn't mean they couldn't be upgraded in an existing contracting plant, a contractor plant on Federal property or a true go co, but I believe we missed the mark, if we don't upgrade the technology wherever it is located.

I haven't seen it today in the industry in the way we build these motors, and to me that is the very heart of what we are trying to do; the very heart.

Mr. PACKARD. It would appear to me that the additional facility, the $300 million facility, would replace existing facilities. Would that mean we would find some facilities then become obsolete or no longer occupied as we replace it with the new facility?

Mr. THOMPSON. The Government has no facilities now like we are talking about. I'm sure there are some contractors that could make a case, and I would expect to see it in their proposals, that they could go a ways toward meeting our intent or in their view, the way toward meeting our intent, by upgrading some of their own facilities. I would expect contractors to make that point.

Mr. PACKARD. We have not to this point asked for any input from the contractors as to what they would have available in terms of facilities?

Mr. THOMPSON. That would be what we would solicit in our Phase B, and we would have the contractor very heavily involved in these upgraded facilities, and if indeed we build new facilities, they would be built by the contractor. That would be our intent.

Mr. PACKARD. Cost, of course, is going to become at least a portion of the driving forces as to what kind of decision is made by the Committee. We are now struggling, as you know, in our budget, trying to keep it simply up to where the President's proposal—we have not been successful in this body. Then we have other major projects, some related to the space program, that are no small projects, the superconducting super collider and others that we are concerned about financing.

Has OMB given you any response to your Option III proposal?

Admiral TRULY. We have cleared this entire acquisition strategy and plan with the OMB, with the clear agreement that the monies that we will go out and spend on this proposal are Phase B study monies leading up to the President's FY 1989 budget. There's no question but that this advanced solid rocket motor program will have to compete in that budget, both within NASA, the Administration and then finally within the Congress.

Mr. PACKARD. Relative to costs, we are talking about the heavy lift vehicle somewhere in the future. You've indicated in your testimony that these motors would be completely usable for a heavy lift launch vehicle.

Have you calculated the cost savings that might incur as we design for the heavy lift vehicle down the road, if this becomes a part of that design?

Admiral TRULY. No, surely if a heavy lift vehicle becomes a reality, that will be a cost trade that we will have to make. The heavy lift launch rate will be relatively small. The real savings and the advantage of a derivation of the shuttle system in a heavy lift vehicle is that we can take advantage of our present infrastructure, the

VAB, the pads, the MLP's down at the Cape, and we would fly the heavy lift vehicle in conjunction with the shuttle, and get probably 3 to 4 flights per year, which would up the production rate required for tanks and rockets, including the solid rocket motor.

Whether that would be a driving difference, we would have to wait until we knew precisely what that program was, what the production rates were and so forth. It would tend to lower the per unit cost, I would think.

Mr. PACKARD. Do you anticipate there would be any requirements for changes in our other existing launch facilities, those at Kennedy or at Vandenburg and other launch facilities, or landing facilities?

Admiral TRULY. Caused by the advanced solid rocket motor?

Mr. PACKARD. Yes.

Admiral TRULY. No.

Mr. PACKARD. They would be able to use unchanged the existing launch facilities and landing facilities?

Admiral TRULY. That is correct. That would be a requirement on the system. Now, I should point out that there would be a facility change involved if we were to go finally to a monolithic design because as you know, it's extremely heavy, we would need lifting cranes and things like that. As far as the launch pads, the launch system itself, the shuttle, this motor would be directly compatible. As a matter of fact, for some period of time, there would be a period of time to maintain the flight rate that we would probably be flying some flights with the redesigned motor, some with the advanced, until we phased all the redesigned motors out and were completely on the advanced motors. There wouldn't be a facility problem with that.

Mr. PACKARD. Do you anticipate that we could maintain the proposed flight rate of 12 to 16 per year, while we are working toward the advanced motors?

Admiral TRULY. Absolutely.

Mr. PACKARD. Those would be two separate tracks that would not impact each other?

Admiral TRULY. This wouldn't have an effect. Our commitment is to generate whatever sustainable flight rate we can. This development would be essentially off to the side and coming along when the motors were developed. We would have a phased in plan so that production rates and assembly rates and flight rates are matched. The basic flight rate wouldn't be driven by this motor. It is driven by orbiter processing, KSC work flows, et cetera.

Mr. PACKARD. Let me just return if I may for a moment, Mr. Chairman, back to the second sourcing question and then I'll conclude.

Could you give us your best estimate as to what the cost comparisons might be in terms of savings achieved in a second sourcing, if any? If you would rather respond to that formally later, that's fine.

Admiral TRULY. I think that the study that we made that we previously discussed will give you the numbers from that study. Our studies indicate that at these production rates, there are no costs, there are no economies achievable. It's just exactly the opposite. At these low rates, as a matter of fact, as I said earlier, the earlier study showed that it was not economical from just a cost point of

view, and we are trying to stress that even though cost is vitally important, it's not the only important thing. Even at a flight rate of 24 per year and splitting that, it's not economical. As the rates go down, that loss of economy becomes more and more pronounced.

Mr. NELSON. Would the gentleman yield?

Mr. PACKARD. I'd be more than happy to yield.

Mr. NELSON. Let's take what many people think to be the expected flight rate, 12 a year, given that 12 a year, what are the economies or diseconomies from your perspective, with regard to a second source on this interim redesigned SRM between now and 1995?

Admiral TRULY. I'm hesitant to answer because the earlier study is the only cost data that I have here today and it was based originally on—it started with a 24 flight per year. That estimate shows that starting at 24 flights per year and splitting the business, in other words, taking the prime contractor down to 12 production sets per year, his increase in costs was 29 percent. If you took that same contractor down to half again, half of 12 to 6, the inefficiencies of that are in excess of 50 percent additional costs on the prime. I'm not sure that answers your question but this previous study shows that the lack of economy is huge.

Mr. NELSON. If the gentleman will yield for one second here and let me finish this up. What I would like before we go to mark-up, Admiral Truly, is I would like some specific projections from you on the basis of a 12 per year flight rate, as to your contention of the diseconomies of scale, of costs, by going to a second source on the interim redesign.

Admiral TRULY. We'd be pleased to develop that for you.

Mr. NELSON. I need that soon. I don't want that the day before we mark-up. I need it right away so that we can subject that to intense cross examination.

Admiral TRULY. We'd be pleased as quickly as we can to develop that data for you and work with you to make sure it's data you can use. We are very interested in that part of this particular subject.

Mr. NELSON. Can you have that for us next Tuesday?

Admiral TRULY. I'll do my best to try.

[Information to be furnished follows:]

[See charts from April 29, 1987 briefing.]

Mr. TORRICELLI. Will the gentleman yield?

Mr. PACKARD. I'd be happy to yield.

Mr. TORRICELLI. First, I'd like to compliment the Chairman. I think he has gotten to the heart of the issue and that is exactly what we need to see to make an informed judgment on this issue.

I was startled, however, in your reply, Admiral, that I would have assumed that since second sourcing immediately was an option, as you presented it here today, that this is an analysis that you have gone through and facts that you have gone over and that are readily available. Please assure me that in answering the Chairman's question today, we are not conducting new analyses or research.

Admiral TRULY. In the time available, what we will have to do is take a look at previous studies, data that we have on costs and production rates and assimilate that.

Mr. TORRICELLI. Admiral, you have come before this Committee today discussing various options for proceeding with a massive Federal contract and presented on that screen that you have looked at the question of going to immediate second sourcing and a variety of other options, and you have chosen Option III.

Admiral TRULY. Yes.

Mr. TORRICELLI. How was it you chose Option III and dismissed the concept of immediate second sourcing if these numbers have not already been gone over to the point of exhaustion? It appears to me that the Chairman is asking you to do no more than pull a page out of an analysis that has already been concluded.

Admiral TRULY. I don't disagree with that. What I was reporting to you was a study that was done in 1984. My only hesitancy had to do with the fact that that original study was based on a starting point of 24 flights per year and cost analyses and you can deceive yourself and I don't want to deceive myself or——

Mr. TORRICELLI. I agree. If the gentleman will continue to yield, I guess my point becomes this; we are now talking about a different design and a different flight rate, a different set of circumstances.

I would have sat here and didn't ask but rather I think was entitled to assume that in dismissing the second sourcing option immediately, you went back and looked at second sourcing, putting all of those factors in and re-studied the issue.

Are you now suggesting to me that you are going to now send that data to us based on the 1984 report and that it has not been re-studied to exhaustion before you came with this recommendation?

Admiral TRULY. No. The cost analyses were done. They are not on the tip of my tongue. I'm told that we have the data and can provide it to you.

Mr. NELSON. We will keep this session in session until such time as a courier arrives and let's just recess the Committee and you get whoever in your office to courier over that piece of information. The Committee will stand in recess.

Mr. LUJAN. Mr. Chairman, some of us haven't had a chance to ask any questions.

Mr. NELSON. All right. In this particular case, can you direct someone here on your staff to go and make that phone call while we continue with the questioning?

Admiral TRULY. Certainly.

[Pause.]

Admiral TRULY. Mr. Chairman, obviously, since this is a specific question, we don't have this data pulled together in a clean package. It is in the technical analysis of the Block II studies that we have previously submitted. What I propose to do as quickly as we can is to have our staff help you in pulling that data together as best we can so that it is in a form that can best answer your question.

Mr. NELSON. You are saying that somebody can do that while this hearing continues and bring that over to us?

Admiral TRULY. We can start that process and work, and if it can be done before the hearing is completed, we will certainly do everything we can to try.

Mr. NELSON. All right. Let's try that.

Mr. Perkins?

Mr. PACKARD. I haven't concluded.

Mr. NELSON. I'm sorry, Mr. Packard.

Mr. PACKARD. I yielded and yielded and yielded but I wanted to complete one further question. I'm very happy to yield for the questions.

One last question, Admiral Truly. This question could be applied to both the second sourcing question as well as the advanced motor design and development.

Would we be injecting a new set or could we be injecting a new set of safety and quality assurance concerns that is already on line with the existing single source?

Mr. THOMPSON. You mean could we be doing anything in implementing true second source, a second source that would perhaps subtract from our safety?

Mr. PACKARD. Correct.

Mr. THOMPSON. It goes back to the Chairman's initial question to me and that is can we at Marshall do the job we have to do to fly the first time safely and at the same time put the proper resources on this advanced solid rocket motor, and I answered yes, and I believe that because I've looked at it hard.

The heart of your question is do we have the resources and the wherewithal to press on with Thiokol, make that redesign work, qualify it, in addition to that, bring on a true second source, another guy to make the same design, get him all qualified, evaluate his test program, and I hope at the same time, do the real job, and that is get working on the advanced solid rocket motor. I suspect not, then we would have to back off of something.

Mr. PACKARD. The natural question that has to follow is what would then be the purpose of a second source, if quality assurance and safety would be available and required through the prime source or the single source, what's the function—normally, what is the function of a second source? Cost would be one, of course.

Mr. THOMPSON. The second source is to certainly bring in the cost competition and in doing so, and this is more intangible, but I would hope that in any kind of competition, you also bring to the table the competition of quality, so the quality improves because now the Government can select. That's certainly much harder to measure than the costs. Dick is going to get the data or the staff is.

Mr. PACKARD. In this case, you feel that quality would be more difficult to achieve with a second source?

Mr. THOMPSON. Only because, and I alluded to it a little earlier, and that is I had a concern even with our own people in Thiokol in trying to have too many back-ups, small derivatives of what we are really talking about, too many back-ups, so we have too many balls in the air and we really don't do right our baseline design. Now, with time, I think we can start to look at this.

It's a big task. It's a big task for us to go fly in 1988 safely, get properly qualified, start working with a true second source and at the same time an advanced solid rocket motor. I believe if we decide collectively we have to do that and we have to prioritize, we have to get the next flight going and do it safe, if we prioritize a second source over this longer range thing, I think it's a fundamental mistake because a true second source is not going to, from the

facilities I've seen, is not going to substantially increase the quality of the product.

Mr. PACKARD. Thank you. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Packard. Thank you for being so generous with your time in yielding so that we could get the discussion going.

Mr. Perkins?

Mr. PERKINS. Thank you, Mr. Chairman. I'm really more interested in listening today than getting involved in the discussions. At this time, I think I am just going to pass and wait until we get the data that you have indicated, because that seems to be the heart of where my interest is in this particular hearing today

Mr. NELSON. Mr. Skaggs?

Mr. SKAGGS. No questions, Mr. Chairman. Thank you.

Mr. NELSON. Mr. Lujan?

Mr. LUJAN. Thank you very much, Mr. Chairman.

Mr. Thompson, it frightens me that you say with a second source, we wouldn't improve the quality, because we certainly didn't have the quality with just one source.

Mr. THOMPSON. No, I said it would be harder to measure. I would expect that you would get the cost competition, as the Admiral indicated earlier, with our low rates, the overhead is going to make that uneconomical, but we are going to get you the data. I do think you would get some quality improvements between the two contractors, neither of which have the facilities in place to really do the things that have to be done over the long haul.

Mr. LUJAN. Mr. Thompson, one contractor has said that if there would have been 2 competing motor contractors, that the accident would not have happened. That's been in the press.

Mr. THOMPSON. The basic problem we had in the accident, in my judgment, was not one of quality control. We had the wrong design. If we don't have the right design in this redesign, 4 second sources isn't going to fix that problem.

Mr. LUJAN. But one of the original bidders wanted one of the things you are now looking at, and that's just one solid——

Mr. THOMPSON. You are talking about the monolithic?

Mr. LUJAN. Yes. Perhaps if you had the 2, if you had just one solid motor or casing, then that would have eliminated the joints and at least that accident wouldn't have happened.

Mr. THOMPSON. If we had the right design in at least one joint that we have to have with the monolithic, then there is something to be said for that. We are very interested in the monolithic. I think there is some work to be done there. We want to give it a fair shot on this go around.

Mr. LUJAN. Let me address how we do business in the future because that is of some concern. You are no stranger to all of the controversies surrounding giving additional business to Morton-Thiokol, that many people feel they have been rewarded because of the accident with additional work.

Now, what made that very, very difficult, for you to look at a second source was that—or going to somebody else to do it is that Morton-Thiokol owns the facilities. I guess that's one of the decisions that you are looking at now, whether the Government should

own it or whether we should contract with someone that already owns the facilities.

I would strongly urge that the Government own its own facilities. We are going to pay for them anyway in the long run. It is a lot easier to change contractors if you own the facilities and you are not satisfied with the quality of work or the progress.

From this member's point of view, I would urge you to look at the option of owning the facilities rather than doing business with contractor owned facilities.

That's all I have to say, Mr. Chairman.

Mr. THOMPSON. That is a very good point.

Mr. NELSON. There is a recorded vote on. The Committee will recess. We will go over and vote and we will return and resume shortly thereafter.

[Recess.]

Mr. NELSON. We will resume. Let me call on Mr. Buechner.

Mr. BUECHNER. Admiral, very nice to have you here. I'm sorry I was unable to attend the very first part of the hearing.

I'd like to start off by just generally complimenting you. I think you have the right attitude. The Agency has proceeded looking not only over its shoulder but to the future. I know that you catch a lot of criticism from a number of sources. I think most of us on this Committee are very pleased with the efforts you have made to not only improve the image of the Agency but in this particular instance, working towards a much better vehicle and a much better program.

Admiral TRULY. Thank you very much, sir.

Mr. BUECHNER. I guess in the questions you have been asked previously, not to be redundant, are there any things that you would like to add to amplify what are in your prepared remarks, either in response to some of the questions that have been asked or just to point out why you feel one option may be better than the other or something you would like to add to amplify those previous statements?

Admiral TRULY. If there was something in this hearing, a message that I could try to get across, and this would be a repeat of something I said earlier, but I would like a chance to say it again, and that is that the most important thing that we in NASA have to do, I think, is over the period of the next several years, and it turns out this proposal dovetails with about where I think we can correct our problems in space transportation, but over the period of the next 5 or 6 years, we have to have a forward looking plan so that we arrive at that point in time with a balanced space transportation capability. It involves the space shuttle. It involves expendable launch vehicles. I think it involves heavy lift capability. I think it involves something like this proposal, an advanced solid rocket motor.

We and you are working on a desperately hard problem but if this nation and its civil space program is going to be positioned, be enabled to take new directions, we have to fix this transportation problem. We are working desperately hard to do that. I guess it's in that context that I believe that this advanced solid rocket motor proposal makes ultimate sense.

Mr. BUECHNER. I appreciate those remarks and I think they give the Committee and hopefully the rest of the Congress a little better understanding of exactly what is going on. Some of the people who have testified previously to both this Committee and the Full Committee, I know have expressed a varied degree of concern. For what you add to it and amplified, I certainly appreciate it.

Just one or two other short questions. What would happen if the redesigned motor that Morton-Thiokol is working on now would not be adequately safe? You wouldn't consider using it; would you?

Admiral TRULY. No, sir.

Mr. BUECHNER. If it is safe enough under redesign, would you need to go to an advanced motor beyond that?

Admiral TRULY. We certainly could fly the shuttle system with the redesigned motor but accepting the massive amount over the years of quality oversight, because it is going to be a safe motor. By the time we test it, instrument it, fire it, we are going to be satisfied that it is as safe as you and we want it to be. When you look at the shuttle system operating from 1988 through 2010, I think, 2005 to 2010, and consider the fact that we could invest in a motor where the industry was upgraded with processing techniques, automation, quality, at some expense, but would position ourselves starting in late 1993 to be using that advanced solid rocket motor, I think that's a good trade.

It is a trade. It will have to battle its way with other priorities right in my budget, as a matter of fact. It will have to be prioritized with heavy lift vehicles and engine improvements and other things. I think it's the right trade to make. I think it's the right plan to start out on and that's the reason that I recommend it.

Mr. BUECHNER. I have one last question. Legally, and I'm sorry if this was asked before but I don't know the answer, legally, would it be possible for NASA to hold a second source competition in order to obtain firm information as an example, to determine if this procurement philosophy would save the Government money on this program, and then cancel the procurement if it found the second sourcing would cost more than it could save?

Could you do that legally?

Admiral TRULY. I'm neither a lawyer nor a procurement expert but it's my understanding that our regulations prevent us from going out on a competition, unless we have an intention of building that system or at least obligates us to fairly evaluate the proposals and if they meet our requirements and the program gets approved, to move out. I don't know. I don't know if that regulation could be waived or not. I think it would be grossly unfair, for example, if we have an argument on cost per unit or cost per flight or any other specific thing, to ask companies to in good faith propose and go to their expense of proposing, unless we were serious. We ought to be able to get information like that in some other way.

Mr. BUECHNER. Thank you. That's all the questions I have, Admiral. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Buechner.

Have you received any kind of comments from any of the advisory kind of committees such as the NASA Advisory Council or the National Research Council or the Aerospace Safety Advisory Panel, regarding this plan to develop the advanced solid rocket motor?

Admiral TRULY. No, Mr. Chairman. I have not personally talked to any of those individuals or groups about this particular proposal. I do think and I would suggest if you would deem it important to get that kind of an input, particularly from our NRC Oversight Committee, because they have worked very closely with us since the accident or during the recovery. That's Dr. Stever's Committee. Believe me, they know what we are doing and they are not hesitant to give their advice or suggestions. I think that would be good input.

Mr. NELSON. They are going to be here next week. We will ask them that question. That's something that I think would be helpful.

Admiral TRULY. I have not personally talked to them.

Mr. NELSON. Okay. I told you at the outset, going to the Block II advanced SRM, I instinctively agree with you, that's where we need to go. A lot of that is coming from just plain instinct. Let me ask you specifically, you imply that the advanced SRM is safer in the long run than the redesigned present SRM.

How do you quantify that? How do you say it is safe?

Mr. THOMPSON. Let me take a cut at it. I'm not sure I can quantify it. I do believe with the test program that we have laid out and all the eyes we have focused on our redesign, that we will go back to flights safely or we won't go. I believe we can sustain that for some period of time. Obviously, with our proposal, we have to do it for 5 or 6 years.

When you talk about several decades, two decades, people are going to change, vendors change, bond, glue changes. I worry about being able to retain and transfer all that corporate knowledge over a long number of years. Solid rocket motors are very simple in design but they are very unforgiving in the way you make them.

Yes. I believe we can stay up tight and focus on the job we have to do with this design for some years. We are committed to do that. We absolutely have to do it.

I worry whether the process can do that for the rest of the program and we will be flying motors into late 1998, at the turn of the century, with 1950 technology. To me, it is just dead wrong.

Yes. I think we can fly what we have safely for some time. I would really worry if budgets did not allow us to make, I think, this basic upgrade over the long haul. I think shuttle and the space program, it has as its very foundation the way we get to space, which is what Dick has been talking about, in the solid and the engines. They have to work.

If we can just save one failure over the next 400 to 500 motors we build, this thing will pay for itself in space. You know, yes, it's intuitive, but I've seen enough of the processing to know that I don't want to try this for the next two decades one legged. We have to give it our best shot.

Mr. NELSON. Let me get into some of the specifics you have talked about. You are interested in the increased performance, naturally. A lot of the constraints, however, going out of Kennedy are not the payload, the orbit, but the down weight, in case you had to do an RTLS or a transatlantic abort. Tell me about that, why then do you need the performance there?

Admiral TRULY. Mr. Chairman, I thought about this in preparation and I prepared a little viewgraph. With your permission, can I put it up and talk about it for a moment?

Mr. NELSON. Sure.

Admiral TRULY. Performance is a complicated subject and it involves altitudes and inclinations and all these mysterious space things. It really is complicated. I have tried to simplify it by this viewgraph, because I think it makes a very important point. I think some people have interpreted our desire for increased performance and related that strictly to Vandenburg. That's not the case.

What I have here is a plot on your left of payload capability of the shuttle, 40,000 pounds, 50,000 pounds, 60,000 pounds, the upper lefthand side of that graph. Plotted across the bottom is inclination of orbit coming out of Kennedy. Now, you know many of our flights come out due east at 28.5 degrees, because that is the latitude of the Cape and that's at the lefthand point of the chart.

The range safety limits at Kennedy Space Center are at 57 degrees. We can't go any higher than that without over flying some of the eastern U.S. and Nova Scotia. 28.5 degrees to 57 degrees are the inclination possibilities. As you go farther and farther north, your capability decreases.

That solid line there is what we project as our payload up weight, in other words, our lift capability out of the Cape at all those inclinations, including the decrements we have gotten from increased weight. If you will notice, at 28.5 degrees, we are approximately 50,000 pounds and as you increase inclination, we slowly decrease to probably 36,000 or 37,000 pounds at 57 degrees.

Now, let's talk about down weight limits. On an abort once around, because of the heating and condition of the orbiter, we do have a limit as to the total weight of the orbiter that we can safely land, come through the 2.5 G turn and touch down at a certain rate without damage. That down weight limit today is about 57,000 pounds, which is shown by that intermediate dotted line.

This would tell you that today if we weren't going to do anything different, that we have good balance. We can lift what we can land with on an abort once around. That's not all the facts.

We already have in work analysis and prior to the first flight, we are going to increase our capability on the down weight up to that upper line, which is about 58,000 pounds.

What I am saying is without some performance enhancement, we don't have a balanced system. In other words, our up weight is significantly lower than the possibilities of the down weight. Let me make a couple of other points.

That line is plotted for 160 nautical mile circular orbit. If you went to a lower orbit like 110 nautical miles, that entire line would be shifted upward. You would have more capability because you are going to lower altitude. Let's talk space station for a minute.

Space station altitude is 220 nautical miles. At 28.5 degrees with this capability, I have a dot on that chart that is about 40,000 pounds. In other words, if we don't do anything about performance, we have to plan our space station operations with an imbalance in the system, a system that could lift quite a bit more, but we are not lifting as much as we can.

The obvious question comes about, is this the way we want to operate the last 15 to 17 years of the shuttle program? Now, if you ask me, the answer is no. This isn't logical if we can gain this performance back in some safe, straight forward and qualified way. With the advanced solid rocket motor, we have that option to do.

We think we can get about 10,000 pounds. That would more than balance the due east capability out of the Cape. It would increase by 10,000 pounds the capability in the way we could plan our shuttle support to the space station program. If we had payloads that didn't need all that weight, we could fly the shuttle engines at the lower thrush settings that I mentioned earlier.

You know, you talk about is it clean, can you add it all up, can you say that's worth $1 million, $5 million, $200 million. To me, it obviously is.

My point is, if we are going to go to the expense to do something different with the solid rocket motors, for gosh's sake, it would be crazy to not balance this equation. I appreciate the opportunity to bring it to your attention.

Mr. NELSON. You are talking about down weight on an abort once around. Is it the same whether it is an RTLS or TAOA?

Admiral TRULY. They differ. It's principally because of the thermal conditioning of the structure of the orbiter. For example, if you are on an RTLS back to the Cape, you haven't been in orbit yet. The duration of the entry and the entry down range is a little bit different on an abort once around. We have to get our technical minds at work to look at each of these cases, the AOA entry, RTLS, each of the entries differently. I'm not personally familiar with that. They are all different cases.

Mr. NELSON. Without getting into all the technical stuff, what you are saying is the down weight is not the constraint, that in every one of those cases, it is the up weight that you need to improve the performance?

Admiral TRULY. That's right. We have the opportunity here to increase the up weight and with no constraint caused by the down weight.

Mr. NELSON. You don't have to worry about the size of the payload if you did a transatlantic abort going in and running off the runway? That is not the constraint here?

Admiral TRULY. That's right. That would not be the——

Mr. NELSON. The weight constraint.

Admiral TRULY. Right. In other words, to put it another way, I am not proposing putting in performance into the system that we couldn't use because of a down weight constraint. That is not what this proposal does.

Mr. NELSON. Okay. Now, while we were over on the Floor voting, you had a chance to get together on some of your figures. I have some figures here that the staff has worked up for us.

Admiral TRULY. Mr. Chairman, the staffers that we sent back to my office, are not back yet. I have not developed any other data during the recess.

Mr. NELSON. Let me have you respond to this; Terry, you have a copy of Dr. Dawson's calculations there for the members of the Committee?

This is predicated on 16 flights per year, not the 12 at which I asked earlier, but this is the data and it is NASA's data on 16 flights a year, in this report on the proposed acquisition strategy and plan.

What this is telling me, and you tell me if this is the correct interpretation, that under a second sourcing where you would have a second source start to produce motors in 1991, that under the existing Thiokol contract out through 1993, the unit cost would be about $24.6 million. The unit cost, we are talking about a pair of SRB's. Under the second source, under your data, the second source unit cost would be $28 to $29 million, starting in the years 1991, 1992 and 1993, which is about a 15 percent increase in costs.

Where the choice may be made to go to a single source, coming out of the second source competition, that unit cost would be in 1992, $22.3 million; 1993, $21.7 million; 1994, $22.2 million and thereon, on the basis of 16 flights per year.

Is that a correct analysis of your data, which is a 10 percent decrease in costs? Is that correct?

Admiral TRULY. Yes, and I will get Mr. Thompson to comment. After looking at the Block II studies that the contractors did and evaluating them, it was assumed that if we were to select from that re-competition a new single source, that there would be a savings from the per unit costs and that is a value of the competition. That savings is about 10 percent.

Mr. NELSON. Okay. If you are going to get a 10 percent decrease——

Admiral TRULY. That estimated savings is about 10 percent.

Mr. NELSON. If you are going to get a 10 percent decrease, then why wouldn't that be what you would want to have? You inject a new competition in this thing. You get the efficiencies, cost efficiencies as a result of a new competition and you are saving 10 percent a year on each of your unit costs, up until the time your Block II is ready to go into effect.

Why wouldn't you proceed in that manner?

Admiral TRULY. Let me make sure I understand your question. In addition to developing the advanced solid rocket motor, that we would also re-compete?

Mr. NELSON. Are we in fact having a 10 percent decrease in unit costs?

Mr. PACKARD. Would the Chairman yield for a question?

Mr. NELSON. Sure.

Mr. PACKARD. So that I'm clear on what we are talking about. I sense we are talking apples and oranges a little bit here. First of all, these are on the assumption that we will continue to use the SRB's, the upgraded SRB's beyond 1993 or beyond 1994 or 1995, at the rate of 16 per year.

Mr. NELSON. I'm not making that assumption. I am making the assumption their Block II acquisition kicks in about 1995, which is what they have testified to. The question I have laid before the Committee is, if you are getting a 10 percent savings in an unit cost as a result of a re-competition up until that point, why don't you want to do that? I don't know the answer to that.

Admiral TRULY. Frankly, if we were in some business other than the space business and not so worried about quality, reliability and

ability for the Marshall Space Flight Center to oversight, and the only question was cost, that might have some merit. That would be the wrong thing to do, to go into the public expense and to invite the problems in oversight and the overload on the people that are trying to get back to flight to have an interim period of a hoped for but estimated 10 percent cost reduction for a total of about 10 motors.

Mr. NELSON. What are the hazards? You said that would be the wrong thing to do. Explain what you are thinking.

Admiral TRULY. Well, Mr. Thompson a minute ago commented from his view as Director of the Marshall Space Flight Center. I took this job with a commitment that whatever we did I would make no decisions where in my opinion the system was left in a less safe or less comfortable position than when I arrived and I'm going to keep that commitment.

I am extremely concerned that we would build two copies of this same motor on the basis of cost. Furthermore, I'm also of the opinion that the cost would tell you not to do that. I am concerned that the Marshall Space Flight Center could develop the capability to provide the safety, quality, oversight to two contractors that are building solid rocket motors with the processes that Morton-Thiokol is building today. I've said several times this morning and I can only say again my personal opinion.

If we are going to do something to gain the advantages of competition, we must address this out year need for doing the right thing, and that's the reason we have worked so hard to try to make this proposal a balance between open competition with everybody involved, using or inviting the availability of new designs, getting our performance back, so we can operate for the last 15 to 17 years of the shuttle program. Nothing else makes sense to me.

I am bothered about their capability to oversee two contractors. I know what they are doing now, trying to get us back to flight and oversee the corrections that we are making in the design with one contractor.

Mr. NELSON. What you are saying is that you just simply don't have enough manpower and expertise to oversee the competition for a Block II design while at the same time, oversee a re-competition on the existing redesigned SRB's?

Admiral TRULY. We can oversee the competition for a new design. In other words, that development program. That contractor would compete. We would have a Source Evaluation Board. He would be selected. He would build a facility or would modify a facility and he would qualify that motor. That in itself would be in parallel to the flight program.

None of those motors would fly until that was accomplished. When that was accomplished, we would phase out the present contract, phase in this new motor and we would be in that new plant with that new contractor, whoever he might be. We can do that.

What I am worried about is building two varieties of the same brand in two different plants with two different contractors and the ability to blanket both of them with the same level of confidence. That is a judgment call but you asked what my concern is, and that is what it is.

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Mr. NELSON. Mr. Packard, you wanted to complete and then Mr. Torricelli.

Mr. PACKARD. I think there are some things left out of these figures that I need to make certain I am correct. Did I hear earlier, Admiral Truly, in your testimony or answering questions, that it would cost from $160 to $200 million to qualify a second source?

Admiral TRULY. That's correct.

Mr. PACKARD. That's not plugged into here?

Admiral TRULY. No.

Mr. PACKARD. According to my calculations, from 1991 after second source and then single source that second source, as you have your bottom figures, from 1991 to 1995, when the advanced would come on line, you are talking about 4 years. You would recoup $115 million, just in excess of $115 million of the $160 to $200 million that it would cost to qualify.

To me, it would be a loser rather than a gainer. To the company, they could furnish it to us at a 10 percent decrease, assuming these are correct, these figures are correct, but when you look at the entire picture, it would still be a loss, or could be. That needs to be corrected.

Certainly, if you produce figures of your own similar to these, we would want to see the whole picture and make sure that all the figures are plugged in.

A couple of questions that I did have, Mr. Chairman, if I may ask, in reading over some of the advanced material that you provided for us, earlier material, I understand there is an overlap of a couple of years when we move from the redesigned SRB's to the advanced SRB's, during which I presume retrofitting would be taking place or the new SRB's would be put on line as we launched during that window.

I would be interested to know just how logistically that would work; how long it takes to retrofit each shuttle. I presume as it comes on line and is delivered, the new advanced, it would simply replace the old redesigned SRB.

Mr. THOMPSON. Yes. Basically what we would do, until we could get the new facility and the new contractor, whoever it is, up to the maximum flight rate, we would have to fly off the other redesigned motors. We estimate that would probably take about 2 years. We would just fly them probably on payloads that didn't require say the performance of the upgraded motor, but there would be an overlap of 2 years while we bring the new guy up to the rates so he could support the total program.

Mr. PACKARD. The new Challenger or the Challenger replacement would require no change in design, it would still be designed just like all the other shuttles?

Mr. THOMPSON. A ground rule would be that the orbiter should not know which motor they are flying.

Mr. PACKARD. The second thing that is more general, Mr. Chairman, it would help me, simply because I think we are talking with those that have an excessive amount of experience with single source versus second source; I would be interested to hear what your evaluation is and justification, the pro's and con's, of single versus second sourcing.

We do both in Government procurement, particularly in military and in our civilian space program. What do you see as justification and good reasons why we would single source or why we would second source? Conceptually, I'm looking at now. Under what conditions would you accept a single source in preference to second sourcing and vice versa.

Admiral TRULY. Conceptually—I'm a great proponent of dual sourcing. It creates competition, lowers price, but you have to do it where you can. I think we should not sole source, the Government should not sole source in any event when there are conditions when we can do otherwise.

I spent over two hours yesterday on a proposed small sole source on a small computer program at the Johnson Space Center that we have to have to develop a tracking system for anomalies, trying hard to find a way not to do it.

I think sole sourcing should only be done when the circumstances drive it.

In this circumstance, I have a great concern that goes beyond cost and you can take performance out of it, with having two sources of one motor and us flying that on the space shuttle. I just worry about that. I don't know how else to say it.

We would have to be as hard as we are on ourselves to try to make the one contractor do it right, then we would have the obligation to do that twice. That bothers me.

Mr. PACKARD. In your proposal, and I think many of us and most of us perhaps have the same inner feeling about dual sourcing, we feel it is fair, the more competitive way of doing it. That's almost American.

Why then are you recommending single sourcing with the advanced design?

Mr. THOMPSON. Could I answer this? Let me try to step back a little bit and address in my own words some of the pro's and con's because we went through and did do a fair evaluation, at least I think, in these Options I, II and III.

If you try to carry two guys along in parallel and split the buy, to me, it is going to be more expensive than where we are now, and I will use the current data that came right out of our report, of about $25 million. I think it is going to be a little more expensive to carry two guys along. If you want to make a decision and now cut it back down to one, you have gotten the benefit of the cost competition and it will be something cheaper, and the study shows about 10 percent, at least on these numbers.

Again, now you are back to a single source. You have gotten the competition of two guys. There is an advantage if you want to stick with two, if you want to pay the price, and that is if something happens to one, then you can always lean on the other man.

The way we have laid the thing out, that really doesn't address the real shortcoming in the solid rocket motor engine. I made those points and I won't go back. We end up with basically the same manufacturing capability, so we are not making a better quality product. We do have the benefit of the competition with the same old facilities, and I'll use that term, and that's an over statement, of competition, to see who can make the best product with the older facility. There is some slight advantage to that.

The second source, if we didn't worry about our advanced solid rocket motor, could do it faster. That's a plus. That's a pro. You don't wait until 1993. You could do it in 1991 and there may be a contractor out there that says you can do it in 1990. You gain several years on that.

Again, in the middle of this next decade, by 1993, 1995, we are going to be basically with 1950's technology. It's my own judgment, to address your question, and there are differences of opinion within NASA, I don't want to get back in the position with now upgraded facilities at a contractor plant where if we have a problem with him, I'm right where I am today, and that is if we want to second source, we want to start all over again, I would rather let it be a Government owned facility where we put the investment in the tooling and if we have a problem with that contractor, we can roll them, and it would bring new management in, but basically the workforce would be, I suspect, there would be a lot of synergism.

There are other thoughts within NASA on that. Dick has cautioned us in our Phase II, our Phase B, that we are not zeroing in on that. It's a broader look. We are open minded, but it has that shortcoming. That is, we may end up in the mid-1990's right where we are today, highly dependent on one individual and one company. If we want to parallel, have a true second source of our advanced solid rocket motor, that's even more expense.

We have those things, those decisions to make in the future, the Phase B is structured to get all the facts together. I'm going to right to what I think—I am biased in this—is a good modern facility that we require the contractor to perform, it's open competition, if you don't perform, we roll it and get somebody else.

There are advantages to the second source, and I've talked to Mr. Torricelli before, he makes a strong point. You can do it earlier. I don't believe the cost trade is there once you pay the $160 to $200 million up front investment to get them qualified. You are not going to fly them that long, if indeed we bring on the advanced solid rocket motor, and to me, that is the very heart of what we should be doing.

Mr. NELSON. Mr. Torricelli?

Mr. TORRICELLI. Thank you, Mr. Chairman.

To put this in perspective, if you would permit me, with all respect, your commitment to competition and second sourcing, I will remind my colleagues, comes from the Agency that has now produced three of the largest single source contracts, the original solid rocket motors, this fix and now looking into the 1990's, over the course of three decades in the United States Government, the largest single source contracts, among the largest.

I, however, would go further in your analysis of the disadvantages of the contracting process, Admiral. In my judgment, you not only do not have adequate personnel to supervise two contractors in the process of producing, I don't believe you can count on having that expertise or that personnel to supervise one. That is why I believe the structure of production has to be changed.

Companies have to be supervising themselves in every product they produce. They have to know that if they are not catching quality problems, if there is not an incentive for improvement in

the nature of this economy, they are in jeopardy, if not for this contract, in its overall relationship with NASA for future contracts.

I would argue that we have to look not at your ability to supervise the two, but the ability of the two to supervise themselves. Hence, a second source.

Let me get to these numbers because I think the Chairman pointed out before these are the essence of the discussion and while I would argue and have argued that second source is the reason for safety, access to space, the reason for a second source, national security is a reason for a second source, let's at least try to settle the cost questions.

The numbers on the second source that are cited here for an average of $28.4 million per flight set, 1991 to 1993, what is the source of that data leading to a belief that there would be a 15 percent increase in cost? What is the data base?

Admiral TRULY. Let me provide that for you for the record. The staff that I asked to go back to the office are not back yet. The generic answer is it came out of our analysis, our technical analysis of the Block II studies that we did.

Mr. TORRICELLI. As a matter of fact, I can assure you without your staff that is the answer. Now, you are giving us numbers to evaluate a second source on this fix through 1995 that is based on estimates supplied by a company for a post-1995 contract on a different technology. You are using that in order to derive these numbers. Fair? Proper evaluation?

Admiral TRULY. I apologize for being slow, but maybe I don't understand.

Mr. TORRICELLI. You are providing to us numbers for us to evaluate cost comparisons now through 1995 on this fix of the solid rocket motors, but the numbers you are supplying us were given to you by corporations who are looking at the post-1995 contract on a different technology solid rocket motor.

Admiral TRULY. These options were built each to their own. In other words, let's say that we do Option I. We discarded all other things and looked at what we felt like in our analysis would be the true cost as best we could project for Option I. Then we did the same thing for Option II and Option III.

Mr. TORRICELLI. I understand. If these numbers are correct, I'm with you. If you feel the safety questions can be answered and the national security questions, I'm with you. But, from what I understand, and I'm not hearing anything to contradict it, these numbers were not submitted by corporations who were asked about their cost possibilities in competing on this contract as a second source through 1995, based on what we are seeing as the fix technology. This is from numbers when they were asked about an entirely different contract and you were deriving these numbers, you were making suppositions about this contract in arriving at these numbers.

Admiral TRULY. Well, as I said, the contractors knew all along what we were doing. They were invited to do the Block II study. They did them. Each was allowed to make their own proposal for a new system. Each did that. Some came in monolithic. Some came in case segmented. They made their own assumptions. We analyzed those assumptions and brought them together in these options that

we felt fairly gave both the Congress and ourselves enough data so that we could pick a course.

Mr. TORRICELLI. I understand that. When all that is said and done, Admiral, from what I described to you before about the sources of this information and the fact that it was provided relative to the post-1995 contract and different technology, am I wrong?

Admiral TRULY. As I said, they were asked to provide information for a new design of their choice, 1995, 1993, 1991, 1994 was there, a recommendation, and frankly the cost estimates came in quite at variance between the contractors, and that's the reason the Government went in and analyzed them all, which we have provided to the Committee. You have that data. To take one contractor's input on cost alone would be a mistake without carefully analyzing it and we tried to do that honestly.

Mr. TORRICELLI. I'm not suggesting you do that. It was suggested before that we are comparing apples and oranges. It appears to me we are comparing apples and bananas here.

Mr. NELSON. Would the gentleman yield?

Mr. TORRICELLI. Yes.

Mr. NELSON. Let me see if I can hone in on that point. You are saying that this data from which we derive from your study is data that not just applies to the advanced solid rocket motor competition that you want to have, you are saying this is valid data in trying to compare costs if you had a second source competition on the existing solid rocket motor as redesigned?

Admiral TRULY. That is Option I. That is what we tried to put together to see what the dollars would be, forgetting all other things, what the dollars would be and how fast we could do it, if we did just what is suggested, and that is go out and have a re-competition, develop a second source, qualify him and start him delivering motors.

Mr. NELSON. The whole thing boils down to the fact as to what is in fact the truth of the figures. Where is the staff?

Admiral TRULY. Mr. Chairman, I have been here with you ever since you asked me to send them there. It's your pleasure. They are good staff and I'm sure they are working hard. I haven't seen them.

Mr. NELSON. Could you go make a call if you could, so we could determine whether or not we stay here or whether we reconvene on another day?

Admiral TRULY. Certainly, if you elect to adjourn, Mr. Chairman, I will have the data to you just as quickly as I can.

Mr. NELSON. We will probably want to do that, have you come back up here so we can have this direct kind of dialogue with the data.

While we are waiting, let me just do some clean-up stuff here.

Mr. TORRICELLI. I think, Mr. Chairman, the point at which we are going to find ourselves is while the data is helpful, understanding its source and what it means will require not only that the staff come here for their evaluation of how they derived these numbers, because it is my belief that we are dealing with derivative numbers, but also to have a variety of contractors, including Morton-Thiokol, who I am not singling out on this, to come forward

and to ask based on each of these levels of technology, each of the different designs, their own estimates.

Because, for example, this is also dependent on an 1991 scenario, which I trust and I have confidence in your evaluation, they could not in fact produce until 1991. I know at least informally other producers are saying they can beat that date. I would like them to say so on the record, to know again whether this analysis is sound.

I will conclude by saying that if these are not derivative numbers, are based on company's estimates of producing this technology and 1991 is a date that is sound, you have made a proper determination. I think they are frankly at this point suspect until we have that hearing and I would urge the Chairman to do so soon.

Thank you.

Mr. NELSON. Mr. Chapman?

Mr. CHAPMAN. I have no questions.

Mr. BUECHNER. Mr. Chairman?

Mr. NELSON. Yes, indeed. Mr. Buechner.

Mr. BUECHNER. I guess what we have done here is we have managed in the last 45 minutes to co-mingle an awful lot of numbers from Options I, II and III. It really would be helpful to this member, and I know this sheet does say Option I, but if we could have at least as much of an line item comparative and showing what basis went into calculating those figures, what were the factors that went into it, so that for us simple minded people, or at least this simple minded person, I don't want to gather anybody else in there, that the charts make a little bit of sense. If we do that, whether it comes from your staff or our staff, I'd appreciate that opportunity, to see just what went into the calculations of each one.

If there were no, for instance, costs in qualifying as an incremental cost or if it is amortized or it is not amortized out, just let us know, put the footnotes in, whatever it is.

Admiral TRULY. We will certainly do that.

Mr. PACKARD. Mr. Chairman, just a point of clarification, I'm new on the Subcommittee. Is it normal for us when we are looking at bids or proposals or RFPs, is it traditional for the Subcommittee to personally review and interview the companies that make the proposals? Do we normally allow the agencies to sift through that and make recommendations or provide us with the information? Do we normally interview each request for proposal?

Mr. NELSON. It is not the position of this Committee to micromanage NASA nor will we. It is the position of this Committee to set policy and to authorize the appropriations for NASA. We have in front of us a major policy question, a major funding question as well. That is, what will be the SRB capability for the future.

A question has been raised on costs and it is the intention of the Chairman that we are going to try to answer this question before we go to mark-up, so that we have the clearest possible answer and get this issue behind us. We have quite a few other issues that we have to handle in mark-up as well.

Admiral TRULY. Mr. Chairman, I've been told it is going to be more than 20 minutes before those guys can get up here. My suggestion would be that we put our fastest effort to reviewing them. I will stand by what we have already given you in our reports. We

will try to boil it down specifically, give you the data that you asked for earlier, based on 12 flights per year and the second sourcing question, and just as quickly as we can, get with your staff, if that would meet with your approval.

Mr. NELSON. I think what we probably ought to do is the first part of next week, all get together and we can do that informally in my office and anybody on the Committee is welcome. We will send you a notice on that. From there, we can go on.

Mr. CHAPMAN. Mr. Chairman?

Mr. NELSON. Mr. Chapman.

Mr. CHAPMAN. Let me ask a couple of questions and find out and perhaps it may not be necessary to do anything else, but has this option or this proposal been bounced off OMB at this point?

Admiral TRULY. Yes, it has. We submitted this entire proposal in the letter that we forwarded to the Committee and the Congress and all of this data to the OMB. They have reviewed it. Basically with the caveat that the funding would be fought out within the FY 1989—for the Phase C/D, the big money, would be fought out within the FY 1989 budget and would be prioritized with other needs, that OMB approved our submission on it.

Mr. CHAPMAN. Approved the submission of the option. Is that any indication that in that fight, it is going to have the support of OMB?

Admiral TRULY. I can't answer——

Is this something this Committee is going to have to—if NASA makes this decision, will this Committee end up having to carry the ball in the authorization and having that in a budget that is——

Admiral TRULY. I can't answer that because there are other competing requirements but I can tell you that this is one of my highest priorities that I am going to submit for the FY 1989 process. I think it is good to understand specifically what we are proposing to do immediately and that is to spend a year with Phase B studies so that we really understand the options of the various designs and can set ourselves up for full and open competition with money available as early as 1989.

Mr. CHAPMAN. At that point, with the 1989 submission, we will be launching, if Option III is the plan that is adopted or some modification of that, a major new expenditure, a major new program, major new equipment and hardware for NASA. I just wondered if you are getting any encouragement at OMB that they not only approve the submission of this but yes, you are on the right track, you are doing this with the full support and blessing of the Administration. It would be nice to know that we have that, at least from the current Administration, or that you have that.

Admiral TRULY. You will have to invite me back this time next year and I'll tell you how I made out. The full support of OMB for future budgets is difficult. They do know what we are doing. It makes sense to them, if we are going to do something, that this is the right thing to do. They have approved our submission.

Mr. NELSON. It would be a sad day if on the question of future thrusts and safety of those thrusts, if Admiral Truly had to go running to OMB for every jot and tittle approval. Unfortunately, there has been a tendency of OMB to require that. Wherever you come

down on this issue of SRB's, let's hope that is not going to be the case, that he can make his decisions as to what is in the best interests of the space program without having to get that specific line item approval from OMB.

We will back you up completely on that issue. As a matter of fact, I have much greater irritations with OMB over lot larger issues. This is one that I don't think that even they would take on.

Let me just ask a couple of questions and then we have to adjourn this meeting.

Under your advanced SRM, is it going to have higher thrust levels or is it going to have longer burn time or is it going to have both?

Mr. THOMPSON. I think it is going to depend on this heads-up, if you run the heads-up trajectory, it is my understanding without getting specific, you want to operate at a little higher pressure level, burn a little faster, so we will have to go through and complete that study. It is basically going to be about the same.

Mr. NELSON. The burn time is the same?

Mr. THOMPSON. It may be a little less, if you try to really optimize on the heads-up trajectory. That's the way I understand it. It's not much different.

Mr. NELSON. The thrust is up?

Mr. THOMPSON. The thrust would be up on the heads-up.

Mr. NELSON. The answer is the thrust level is a little higher but not the burn time?

Mr. THOMPSON. That's right.

Mr. NELSON. What then would be the impact of that thrust change on the orbit? You now have an new SRB that has a higher thrust.

Admiral TRULY. That is the reason that during this period of the Phase B, that we would do an integrated performance and trajectory study between the Johnson Space Center and Marshall Space Flight Center, to make sure that we would not incur an additional and hidden cost in orbiter construction or something like that. One of the requirements would be that the burn profile would be within the present design envelopes of the present vehicle.

Mr. NELSON. Okay. On the redesign of the present SRB, just answer yes or no, is it true that your engineering test model firing for the 51-L type hardware is going to now be on May 23rd of this year?

Mr. THOMPSON. That's very close. I would have said May 20th.

Mr. NELSON. When will the first test flight of the new redesigned SRB hardware occur?

Mr. THOMPSON. You are probably talking about what we call DM-8. We have that scheduled for the end of July and right now we are trying to work it, about a week, so it is either the last week of July or the first week of August.

Mr. NELSON. Thank you, gentlemen. Any further questions?

[No response.]

Mr. NELSON. All right. We will look to reconvening with you early next week.

Admiral TRULY. Thank you, Mr. Chairman.

Mr. NELSON. Thank you. Have a nice day.

[Whereupon, at 12:35 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

# 1988 NASA AUTHORIZATION

WEDNESDAY, MAY 6, 1987

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
*Washington, DC.*

The subcommittee met, pursuant to call, at 1:45 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson [chairman of the subcommittee], presiding.

Mr. NELSON. Good afternoon. This afternoon we are going to hold the last of what have been an extensive series of authorization hearings on the fiscal year '88 budget. The purpose of today's hearing is to explore the relative advantages as well as disadvantages of alternative flight hardware acquisition strategies with regard to how it affects the budget, how it affects fiscal year '88 request on the Space Shuttle solid rocket motors.

The objective of today's hearing is to identify what should be the strategy for future purchases of these SRMs so that we can have the most reliable and economical product for the Federal Government. And in the process of our review, we will ask the contractors that are here today to share with us their opinion regarding NASA's proposal to have an advanced solid rocket motor for the Shuttle as well as their proposal to have a construction of a government-owned, contractor-operated production facility. We will also ask them to discuss any other alternatives that they may believe is preferable to the NASA proposal.

So with this information, along with the testimony that we have received in recent weeks from NASA and others, then, we will be better prepared to make a determination of what action should be taken on this subject.

Now, in our hearing today we will be receiving testimony from our five witnesses: George Brown, from Aerojet; Harry Crosby, from Chemical Systems Division of United Technologies; Bruce Biehler, from Hercules; Mr. James Sides, from Atlantic Research Corporation; and John Thirkill, from Morton Thiokol.

So I want to thank you all for being with us today. We appreciate it very much.

We will enter into the record Mr. Walker's opening statement, and we will proceed in the order that we have listed.

Mr. NELSON. What I would like you all to do, we have a lot of questions and rather than you sitting there and reading to us just your statement, that will be entered in and will become a formal part of the record. We'd like you to talk to us about your opening

commentary. We'll proceed and we'll hear from everyone, and then we'll get into the questions.

Mr. KONNYU. Mr. Chairman?

Mr. NELSON. Yes, sir.

Mr. KONNYU. Mr. Chairman, I wonder if I may also enter into the record my opening statement?

Mr. NELSON. Oh, indeed. Any other members who would like an opening statement, certainly it shall be entered.

[The prepared opening statement of Mr. Konnyu follows:]

CHAIRMAN NELSON...I WANT TO APPLAUD YOU FOR HOLDING THIS IMPORTANT HEARING. A FACT WE MUST DEAL WITH IS THE SOVIETS ARE IN SPACE.

THE QUESTION THIS COMMITTEE MUST ASK IS..."SHOULDN'T WE BE THERE TOO?"

WITHOUT HESITATION OR EQUIVICATION MY ANSWER IS A SOLID AND FIRM "YES"!

HOWEVER, JUST AS THE MAN FROM MAINE SAID..."YOU CAN'T GET HERE FROM THERE WITHOUT A HORSE"...I'LL SAY...YOU CAN'T GET INTO SPACE WITHOUT ROCKETS.

DOES THE CAPABILITY EXIST IN THE UNITED STATES TO BUILD SAFE AND RELIABLE ROCKETS? YOU BET!

A NUMBER OF ROCKET AND ROCKET COMPONENT MANUFACTURERS ARE IN MY DISTRICT AND I'VE VIEWED THEIR FACILITIES WITH A FINE-TOOTHED COMB.

I'M IMPRESSED. IT TAKES KNOWLEDGE...DEDICATION...AND HARD WORK TO BUILD A SAFE...RELIABLE...PRODUCTIVE ROCKET AND THOSE COMMODITIES ARE IN ABUNDANCE IN THE INDUSTRY.

UNFORTUNATELY...EMOTION...AND THE CONSEQUENT DOWNPLAYING OF REASON IS CREEPING ITS WAY INTO THE DECISION-MAKING PROCESS ABOUT HOW TO PROCEED WITH ROCKET CONSTRUCTION.

EMOTION DOESN'T BUILD ROCKETS. IN FACT...NINE TIMES OUT OF TEN EMOTION WILL LEAD YOU TO UNDUE RISK TAKING IN DECISIONS.

LET'S NOT MAKE THE WRONG DECISION BASED ON EMOTION!

WITH EMOTION ASIDE THE PROPER COURSE SEEMS CLEAR TO ME. LET'S LET THE COMPANY WHICH KNOWS ABOUT THE SHUTTLE ROCKET...FIX THE SHUTTLE ROCKET WITH STRONG OVERSIGHT FROM THE COMMITTEE AND NASA.

THAT PLAN WILL TAKE CARE OF THE SHORT TERM.

HOWEVER, THE SHUTTLE HAS GOTTEN HEAVIER AND PAYLOADS NEED TO BE BIGGER. TO MEET THOSE CHALLENGES THE UNITED STATES NEEDS AN ADVANCED SOLID ROCKET MOTOR.(ASRM)

HOW MANY ADVANCED ROCKET MOTORS WILL BE NEEDED FOR THE PROGRAM? TO WHAT SPECIFICATIONS SHOULD THE MOTORS BE BUILT? IT WILL TAKE TIME...PERHAPS 18 TO 24 MONTHS...TO MAKE THESE DETERMINATIONS. IN THE MEANTIME THE ENTIRE U.S. ROCKET INDUSTRY SHOULD WORK ON DESIGNING THE STATE OF THE ART ADVANCE MOTOR.

CONTRACTS FOR THE NEW MOTOR SHOULD NOT BE LET UNTIL THE COMMITTEE HAS A BETTER IDEA OF WHAT THE SPACE PROGRAM WILL DEMAND FROM THE ASRM.

IN CONCLUSION...MR. CHAIRMAN...THE SPACE PROGRAM IS VITAL TO AMERICA AND STRONGER...MORE ADVANCED...MORE ADVANCED MOTORS DESIGNED THROUGH INNOVATION... MUST BE OUR AIM FOR THE FUTURE. OUR COMMITTEE SHALL DETERMINE THAT FUTURE AND I STAND READY TO WORK WITH YOU AND OTHER MEMBERS TO MAKE THIS A REALITY.

Mr. NELSON. Mr. Brown?

**STATEMENTS OF GEORGE G. BROWN, VICE PRESIDENT FOR PROGRAM DEVELOPMENT, AEROJET PROPELLANT CO., SACRAMENTO, CA; HARRY L. CROSBY, VICE PRESIDENT FOR BUSINESS DEVELOPMENT, CHEMICAL SYSTEMS DIVISION, UNITED TECHNOLOGIES CORP., SAN JOSE, CA; BRUCE BIEHLER, GROUP VICE PRESIDENT FOR MARKETING, HERCULES AEROSPACE PRODUCTS GROUP, HERCULES, INC., WASHINGTON, DC; ACCOMPANIED BY P. WARD HILL, MANAGER, NASA PROPULSION PROGRAMS; JAMES R. SIDES, GROUP PRESIDENT, ARC GROUP, AND GENERAL MANAGER, PROPULSION DIVISION, ATLANTIC RESEARCH CORPORATION, ALEXANDRIA, VA; JOHN D. THIRKILL, VICE PRESIDENT AND GENERAL MANAGER, SPACE DIVISION, MORTON THIOKOL, INC., BRIGHAM CITY, UT**

Mr. BROWN. Thank you.

Thank you, Mr. Chairman, and distinguished members of the committee. I appreciate the opportunity to appear before you and comment on the subjects that you have addressed, Congressman Nelson.

We believe at Aerojet that in terms of the NASA program selections they have made that the opportunity is here now for the Nation to invest in a program that would yield through an advanced solid rocket motor program the best possible solid rocket motor for future space flights carrying on into the next century, and that this really needs to be done from the standpoint of safety and reliability; and that to do less than as proposed is really accepting or posing an unacceptable risk to our astronauts and to the Space Program.

The NASA plan for an advanced solid rocket motor program in our view is the best and the only one I think of the four alternative procurement strategies that we're going to comment on that can meet the criteria that I've just talked about. The remaining three, really, entail variations on how to build a sort of a fixed-up design that's 15 years' old at this standpoint and we really need to move farther with that to get the reliability and safety into the program that it requires.

Certainly, the redesigned joints that NASA has proceeded with since the Challenger accident are more reliable and they are safer than they were at the time of Challenger. But there will still be in our view three joints, three field joints in every motor. Now that means that there are six field joints that are flown with the Shuttle and that causes us concern. It means that there are six breaks in the insulation on the inside of the motor, there are six breaks in the propellant, and each of these interruptions in propellant or in insulation is a potential cause for future failure. We consider it important and imperative that all the joints in the solid rocket motors be eliminated at the earliest practical date in order to provide a safe Shuttle for future flights.

We have proposed a design to NASA that eliminates the joints. We gave them our proposal last year. In the Phase A studies that we have just conducted we also gave them specific design solutions that would eliminate the field joints in the so-called monolithic or

one-piece propellant grain. Now this design reduces the failure points actually by over 67 percent, and that's a very significant number, and it greatly increases then the reliability and the safety of the final configuration. So we think that the advanced solid rocket motor option is an opportunity to go in this direction, in the monolithic direction and get this large gain in flight safety and reliability. The other three options of second-source procurement or winner-take-all and so on do not.

We certainly agree with the testimony that Mr. J. R. Thompson offered to your committee which indicated that he also realizes that they could greatly enhance flight safety and reliability through the use of new technology and manufacturing techniques, including a monolithic design which they intend to look at.

The advanced solid rocket motor option offers the industry an opportunity to apply modern state-of-the-art manufacturing techniques which can, in fact, add to and increase the reliability and safety of the final product. In our judgment one of the greatest opportunities for automation that Mr. Thompson talked about and the one that would yield basically the greatest gains in quality, reproducibility, is the process of propellant mixing, transportation and casting, which is a significant portion of the production process in a solid rocket motor. And here, as before, we are recommending to NASA that the process that we call continuous mix is the process that should be used in an advanced solid rocket motor.

I've included with my submittal a brochure which is an economic analysis of comparison of continuous mix process versus the batch mix process which we all employ today in making solid rocket motors. This is a process that we perfected and used on the Polaris program years ago where we had a large volume requirement, and the continuous mix process becomes efficient, economically efficient with large volumes of propellants such as exist in the solid rocket motor or Space Shuttle.

You can certainly automate other parts of a batch process, and this has been done by us and by the other contractors at the table, but you are still handling batches and you still have more people than really need to be involved in the process. As we do batches we have to transport those batches to the cast site and cast the propellant into the motor. That can be automated. You can actually have automatic vehicles that do that, but that is a process that still involves an iteration and another activity that's required.

In a continuous mix process, we can actually take the propellant as it is mixed, transport it through a pipe directly into the motor. And we have, as a result of recent gains in quality verification programs have been able to put together an in-line quality process that can be used on a continuous process like this. And we feel this could be a very significant advance, and it's certainly a prime example of what Mr. Thompson was talking about when he referred to automation being a source of increased reliability in the producibility of the product.

Now in the brochure that I have here, the bottom-line number that you get to when you go through the economic analysis that is here, tells you that the continuous process can be done for about one-third of the cost of the batch process. I want you to realize all I'm talking about is propellant mixing and casting. I'm not talking

about the metal parts that are in the program or anything else. But the propellant process itself with a continuous mix process can be done for about one-third of the cost and with increased reliability and safety. So it's something that I think that in looking at advanced solid rocket motors that it's a system that really should be seriously considered by NASA and we would intend to promote that system with them.

Now this process certainly isn't new to us. We've cast a larger motor than the Shuttle motor, a motor called the 260-inch rocket motor that was done for NASA back in the middle '60s. It was done at a plant in Dade County, Florida. But we did that using continuous mix along with batch mix, and we used them interchangeably. So it produces the same product in terms of the final propellant, its mechanical properties, its burn rate and so on, that the batch process does, but it does it more efficiently.

And there has been concerns raised by NASA in regard to using this process and particularly to our suggestions on the monolithic motor, concerns basically around casting propellant into a motor that now is 120 feet in height. The experience that we've demonstrated to date has been into motors that have been about 80 feet in heighth. We understand what the NASA concern is and we would intend to address that during this Phase C or D program that NASA is about to release an RFP on.

We also understand NASA's desire for increased performance in terms of an advanced solid rocket motor. Even before Challenger, an effort was underway to develop a lighter weight, filament-wound graphite case manufactured by one of the contractors at this table, and the plans at that time also included, and I guess still include, operating the main engines at perhaps 109 or 110 percent of its rating.

With the redesign from Challenger and so on, there has been weight that has been added, into the joint specifically, and so the solid rocket motors and boosters no longer are able to perform to the same payloads that they were before because of this added weight. So there is a need as we go forward in time to be able to accommodate large payloads in the Shuttle, and so the need to increase performance I think is something that's vital to the program as well, and the advanced solid rocket option provides the opportunity then to introduce advanced performance into the system. It can be done with material weight reductions, it can be done with more energetic propellant—there are many ways to do it and most of us have commented on that during the Phase A studies.

Now, also all of the major studies that are going on today in terms of HLLV take note of the fact that it's important to be able to reduce operations at the launch site and to conserve costs at the launch site. And the monolithic design that I have talked about dramatically improves flight safety and reliability but it also eliminates operations required to assemble at the launch site. The operations that now take place in the vertical assembly building in putting the segments, the loaded segments together with propellant in them essentially are eliminated because the booster is now assembled off line or off site to that and introduced into the assembly process as a completed rocket motor.

Turning now to the other alternatives involving procurement of the redesigned SRMs, I think certainly that competition would provide incentives for contractors to improve quality and cost. However, I think that the aggregate cost to the Government can be expected to be higher with two contractors operating at the lower rate now that we have in the Space Shuttle program. In the previous work that was done on second source we basically were looking at a flight model of 24 flights per year. Now I understand we're looking at something—12, perhaps a peak rate of 15, is the area that the hardware would be required to be supplied for.

Now what happens, of course, when you go to two sources is that you introduce some fixed costs at two places that didn't really exist before. When we look at our cost structure, we have certain costs that we say are pretty much fixed and not dependent upon rate. Each of the contractors has to have people that basically interface with NASA or the so-called Program Office, and there is labor associated with that. There's labor associated with the quality program in our plants. There's labor associated with receiving, with the material flow, and these costs aren't necessarily dependent upon the production rate. And so you're looking at, then, two sets of fixed labor costs that essentially have to be amortized over the motor production quantities.

And also, in order to maintain a competitive posture as you go into the program, you're never really going to want to have a 50–50 split on the buy; you're going to want to offer the man who can give you a lower cost a higher proportion of the hardware to be built, and so it's going to be 60–40, 70–30, or some ratio such as that. This means that one of the contractors is going to be operating at a relatively low rate in relation to the other contractor. If you assumed 12 flight sets per year, it means that probably one of the contractors is only going to be producing 4 flight sets per year. And he now has to amortize his fixed costs over this lower quantity, which is going to result essentially in a higher price. A higher overall price to the program.

So we believe that the size of these fixed labor costs in relation to the small quantities will result in higher cost to the Government in spite of the competition.

Mr. NELSON. Mr. Brown?

Mr. BROWN. Yes, sir.

Mr. NELSON. We had allocated 10 minutes to each of you.

Mr. BROWN. Okay.

Mr. NELSON. And we're well over that now, so why don't you sort of bring it in for a landing?

Mr. BROWN. All right.

Mr. NELSON. We'll get back in on a lot of these points with our questions.

Mr. BROWN. I'd like to take the opportunity then to again endorse the advanced solid rocket motor program plan because it does provide for improved flight safety and reliability and allows the application of advanced manufacturing techniques. It also provides for the increase in performance that's required to meet future mission requirements. It allows for continuing competition in that we would endorse also NASA's concept of a government-owned, company-operated new location to manufacture these large

boosters, and that is a way of continuing competition throughout the life of the program.

A comment I'd like to make in regard to the schedule. We believe the schedule could be accomplished faster, perhaps as much as a year, and involved in that as much as anything is the funding cycle and everything that the Congress has to do. We would recommend that the Congress as it proceeds on the evaluation of the NASA request essentially restrict funding for additional procurement of flight motors from the present sole source supplier until such time as you see progress in regard to the advanced solid rocket motor, and specifically to prohibit go ahead on buy three until Phase C/D of the ASRM program is under contract with an accelerated schedule.

We also would like to comment that the level of funding we understand will be put under Phase B studies at, in round numbers, $3 million per contractor is really inadequate to do the scope of work that's been indicated to us so far, and that it probably should be in the range of $5 to $6 million per contractor.

Thank you, Mr. Chairman, for the opportunity to make these remarks.

[The prepared statement of Mr. Brown follows:]

# SUMMARY STATEMENT TO THE HOUSE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

BY

GEORGE G. BROWN

VICE PRESIDENT, AEROJET GENERAL

Mr. Chairman and Distinguished Members of the Subcommittee:

Thank you for the opportunity to appear before you today to comment on Space Shuttle solid rocket motor procurement options.

We, at Aerojet, believe now is the time for the Nation to invest in a program that will yield the best possible solid rocket motors for the Space Shuttle from the stand point of flight safety and reliability. To do less entails an unacceptable risk to our astronauts and our space program.

The NASA plan for an Advanced Solid Rocket Motor (ASRM) is the only one, of the four alternative procurement strategies we have been asked to examine, that can meet this criteria. The remaining three entail variations on how to build a "fixed-up" 20 year old design better and cheaper.

The redesigned joints in the solid rocket motors are certainly more reliable and safer joints than those which caused the Challenger disaster. But there will still be three field joints in every motor or six field joints of concern for every Shuttle mission. That is six breaks in the propellant and six breaks in the insulation which create potential failure points and requires complicated joints with "O" ring seals. We consider it imperative that all joints in the solid rocket motors be eliminated at the earliest practical date in order to provide a safe Space Shuttle for the nation's future.

Aerojet has presented a design to NASA that eliminates all propellant and insulation joints in the solid rocket motors. I

wish to repeat that point. The Aerojet design eliminates all joints in the propellant and insulation of the solid rocket motors. This design, reduces the potential failure points by over 67% which greatly increases the reliability and safety of the solid rocket motors.

The ASRM option provides an opportunity to achieve this large gain in flight safety and reliability. The other three options do not.

We agree with the previous testimony of Mr. J. R. Thompson, the head of NASA's Marshall Space Flight Center, which he indicated that we could realize greatly enhanced flight safety and reliability through the use of new technology and manufacturing techniques, including the monolithic design for failure mode reduction. The ASRM option also provides an opportunity to introduce modern state-of-the-art processes that will result in higher quality solid rocket motors and lower cost through the use of automation.

In our judgment, of all of the processes that are candidates for automation, the one that will yield the greatest gains in quality, reproducibility at lower cost is the propellant mixing, transportation and casting processes. Here we recommend the Aerojet Continuous Mix process in which propellant is made and cast in the motor on a continuous basis rather than in batches as is the current approach. Certain parts of the batch process can be automated but propellant is still made and handled in batches which limits the advantages of automation. For example, robots can be used to transport each batch of propellant from the mixing

station to the casting station. With our continuous mix process, the propellant is transported in a pipe.

The continuous mix process offers substantial cost advantages over the batch process for large solid rocket motors like these for the Space Shuttle. The investment cost for a continuous mix propellant plant is about 1/4 that of the batch process and labor is reduced to 37%.

All of this means that high quality propellant can be produced for the Space Shuttle solid rocket motors using continuous mix for 1/3 of the cost using the batch process. The materials cost is the same for either process.

The continuous mix process is not new to us. Aerojet has previously cast propellants in quantities that are 50% greater than that required for an SRM, but the height of the cast was half that of the SRM. We do not consider casting to the full SRM height to be a concern as there are many ways to accomplish it, but it is a condition that must be investigated.

We understand NASA's desire for increased performance from the solid rocket motors. Even before the Challenger accident, effort was underway to develop a lighter weight, filament wound graphite case and plans included operating the Shuttle main engines at 110% of rating in order to meet mission requirements. The added weight of the redesigned joints and other fixes as a result of Challenger further reduces the payload to orbit capability. The NASA ASRM program provides the opportunity to increase the Space Shuttle payload capability without sacrifice of flight safety and reliability. The other SRM procurement

alternatives do not.

All of the major study (HLLV) efforts to reduce the cost of reliably placing payload on orbit concentrate heavily on reducing the prelaunch activities of the launch site. The monolithic design, spoke of earlier, which dramatically improves the inherent flight safety and reliability also eliminates the operations required to assemble the solid rocket boosters at the launch site. The monolithic booster is fully assembled on delivery. The other options do not offer this advantage.

Turning to the alternative procurement options involving procurement of the redesigned SRM's, certainly competition can provide incentives for contractors to improve quality and cost. However, the aggregate cost to the government can be expected to be higher with two contractors splitting the relatively low production rate. This is true because there are now two sets of fixed costs that must be amortized over the motor production quantities. In order to provide the desired competitive incentives, the production split must be on the order of 60% and 40%. This means one of the contractors must amortize facility investment and fixed programmatic costs over 5 or 6 flight sets rather than 12 or 16 and the "winning" contractor over something less than the full quantity. We believe that the size of the fixed costs in relationship to the small quantities will result in higher cost to government in spite of the competition. For example: In the production of solid rocket motors approximately 35% of the motor cost is fixed and not affected by the unit production rate. If you then apply a 95% learning curve and 80%

competition factor to a 60/40 production split between two contractors, the increase in production cost in about 42% over and above a single source cost.

There are other advantages to having two sources such as assured supply in the event of a production interruption, a surge capability to meet higher rates and an expanded industrial base for large solid rocket motors.

A winner take all competition for the redesigned SRM can provide a one-time gain through competition and a possible change in contractors but provides no lasting competitive advantages.

In fact, rather than various ways of competing the redesigned motor, a far better solution would be a positive response to our proposal of a year ago to manufacture motors in which 51-L type failures could not happen. In April of 1986 we placed in NASA's hands a proposal which would have cost NASA less than $40M in the first year to reactivate our Dade County, Florida, facility to make one piece propellant SRMs which would completely eliminate the field joint failure modes. NASA did not positively respond to this offer. J. R. Thompson and a group of his key staff were interested enough to examine the facility.

We believe that the advantages of continuing competition, or the threat of it, can best be realized with a modern Government-Owned Contractor Operated (GOCO) facility dedicated to the production of SRMs for the Space Shuttle and future HLLV applications. We previously offered the Dade County facility to NASA for this purpose.,

I would like to take this opportunity to again endorse the

NASA plan for an Advanced Solid Rocket Motor (ASRM) that was submitted to Congress on March 31, 1987, because, when compared to the current redesign, it provides for:

a. Improved flight safety and reliability through use of state-of-the-art technology and manufacturing techniques including monolithic design for failure mode reduction.

b. Increased performance to meet future mission requirements and to recover payload capability if NASA proceeds into flight with a redesigned flight joint with its attendant weight growth.

c. Continuing competition with commensurate high quality and reduced costs.

d. Substantially reduced launch operations cost if the monolithic design is selected.

Even though we believe that NASA made the correct option choice and are convinced that the ASRM program will provide superior solid rocket motors for the Shuttle, at lower cost, we are concerned that the proposed schedule does not provide these benefits to the national space program as soon as should be expected from a truly dedicated effort. In this regard we would like to offer the following comments:

a. The schedule, as currently proposed, locks in both the current sole-source supplier (Thiokol) and the current redesigned motor concept through 1994 at a cost of $1.4B. We believe that the ASRM program can be accelerated to provide reliable solid rocket motors for

flight one year earlier.

b. The $3M funding level planned for each contractor for Phase B is not adequate for the planned scope of work. Further, while recognizing the inherent flight safety and reliability offered by the monolithic design concept, NASA believes that the technology necessary for large monolithic SRMs has not been adequately demonstrated. This technology must be demonstrated during Phase B in order to insure that this opportunity to provide the best solution for Space Shuttle boosters not be allowed to slip away.

c. The timing of the FY 1989 funding request for Phase C/D of this program places it in direct competition for funds with the space station, the fourth orbiter and HLLV, thereby tending to ensure its early demise unless this program is given a high priority.

In order to address these concerns, we recommend the following actions by the Congress:

a. Restrict funding for additional procurement of flight motors from the present sole-source supplier based upon progress on the ASRM program. Specifically, prohibit the go-ahead on Buy III until Phase C/D of the ASRM program is under contract with an accelerated schedule.

b. Require increase funding to $5-6M per contractor for the Phase B effort.

Congressional help is needed now to ensure the ASRM program continuation when in another year or two, we all could be lulled

into a sense of false security with a series of ground tests and a few successful flight test under our belts. We should do no less than everything required to provide our space program and our astronauts with the most reliable SRM booster to meet future space slight requirements.

Thank you, Mr. Chairman.

# CONTINUOUS MIXING PROCESS FOR SHUTTLE SRM

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# CONTINUOUS MIXING PROCESS FOR SHUTTLE SRM

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The "Scope" and "Basis" presented were established to meet the program objective of selecting the safest, most economical, proven approach to producing very large solid rocket boosters at a production rate exceeding 12,000,000 lb per year.

The "scope" of the study centers on batch propellant processing versus continuous production. Aerojet has successfully used both processing methods in large scale production and therefore feels uniquely qualified to evaluate the relative merits of each technique as applied to large booster production.

The "basis" used for the analysis is predicated on safety, reliability, and the lowest operating cost consistent with safety and reliability. To this end, it is important that (1) proven processes be used (no significant development effort), (2) process criteria can be immediately prepared so that A&E can promptly be initiated and construction or modification work started quickly, and (3) compliance with all booster specifications can be demonstrated at a minimum cost.



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# SHUTTLE PROPELLANT PREPARATION ANALYSIS

**Scope:** Compare Investment and Manufacturing Costs for Propellant Mixing Options and Mixing Support Operations (Such as Propellant Raw Material Processing for Delivery to the Mix Complex)

**Basis:**

- No Process Development
- Prepare Process Criteria and Proceed Directly to A&E Phase
- Comply With NASA Specifications



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The shuttle booster propellant is a simple formulation and is almost identical to the propellant processed by Aerojet at Dade County, Florida for the AF/NASA 260-in.-dia rocket booster program in the 1960s. Aerojet used both batch propellant and continuous propellant processing on an interchangeable basis for these multi-million pound loadings.

The propellant hazards for this propellant system are normal for propellant production and the ignition sensitivity is low compared to many of the propellant commonly produced within the industry. Aerojet found that the hazards were further reduced in continuous processing because of the reduced quantity in the mixing equipment at any time and the improved temperature control.

The current application requires high volume production for propellant: over 3M lb/month stream rate during booster loading and about 2M lb/month average production rate. This is well above the historical break-even for continuous vs batch propellant processing.

The propellant performance specifications are well established and can easily be met with any of the proven industry method of propellant processing.



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# SHUTTLE PROPELLANT

- Simple Propellant
- Low Ignition Hazard Sensitivity
- High Volume Required
- Specification Established

- Aerojet has Produced Similar Type in Florida Plant (5 to 6 Ingredients) for 260-in. Program
- Similar to our 1.3 Production Propellants
- Over 2,000,000 lb/Month
- No R&D Required, Only Tailoring During Lot Qual



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**The history of Aerojet propellant mixing is summarized here. Aerojet phased out horizontal "dough" mixers in favor of vertical planetary batch mixers and continuous mixers in the 1960s for a combination of safety and cost considerations. In the late 1960s Aerojet ceased continuous processing because we no longer had the large production demand for a single propellant system (an economic necessity for the continuous process).**



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# AEROJET PROPELLANT MIXING HISTORY

## BATCH

1957 — 200-gallon Bramely Vertical Planetary Mixer Ordered

1959 — Bramely VBM delivered but was a mechanical nightmare (VBM activity stopped)

1960 — 30-gallon Baker-Perkins VBM placed in operation

1964 — First 600-gallon VBM production at Dade Plant (5500 pounds/batch)

1968 — First 600-gallon VBM production at Sacramento, began phase-out of Horizontal Dough Mixers

1987 — Currently using 600-gallon VBM unit for the production of a large variety of castable composite propellants

## CONTINUOUS

1957 — Continuous Mixing feasibility examined in Azusa

1958 — Continuous Development program started with Navy Special Project Office funding

1958 — First Continuous propellant produced in UK-100 at Sacramento Pilot Plant

1960 — Demonstration of UK-150 and Polaris Production Plant started (1200 lb/hour mixer)

1960 — Air Force funding development of Continuous Mixing Development

1964 — Second Generation Continuous Plant began production at 4000 lb/hour-mixer up to 4800 lb/hour-mixer

1965 — Lost Polaris Contract, Continuous Mixing Phased Out

1967 — Phased out last continuous plant operation since low production volume made economics unattractive

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Some of the pertinent parameters of operation between shuttle proven batch and continuous mixing systems are displayed on this chart. The most significant differences are the manloading requirements, the amount of explosive ingredient at each mixing site, and the land areas required for safety isolation from non-associated production operations. These factors, of course, translate into costs to produce.



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# GENERAL INFORMATION-1

## Shuttle Motor Propellant Mixing Comparison

9,000 lb/hr Max. Rate Required for 3 Segments/5 Day Wk; 36,000,000 lb/yr

| | Continuous Mixing | | Batch Vertical Mixers | | | |
|---|---|---|---|---|---|---|
| | 1-UK 250 | 2-UK 200 | 3-1,800 Gal | 4-1,000 Gal | 5-600 Gal | 6-420 Gal |
| Maximum Production Capability, lb/hr | 10,000 | 9,000 | 9,600 | 10,500 | 9,400 | 9,400 |
| Batch Turnaround Average, hr | – | – | 8.5 | 6.3 | 4.78 | 4.0 |
| Propellant in Mixer, lb | 1,000 | 400 | 27,000 | 15,000 | 9,000 | 6,300 |
| Propellant and Materials at Each 1.1 Site, lb | 6,000 | 5,000 | 43,200 | 24,000 | 14,400 | 10,800 |
| Q-D Land Area for Mix Complex, Acres | 10 | 18.7 | 83.2 | 75.0 | 66.7 | 65.8 |
| Production Record, lb | None | >5,000,000 | None | None | None | >10,000,000 |
| Operator Labor Men/Day (3 Shifts) | 9 | 15 | 24 | 30 | 36 | 45 |



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The explosive concentrations at the respective mix sites are shown graphical in this slide.



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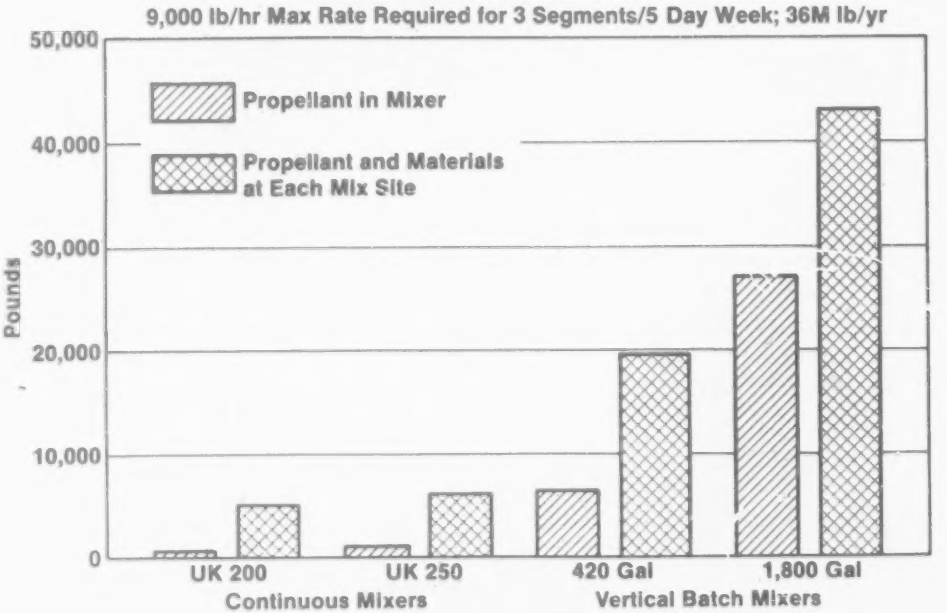
# SHUTTLE MOTOR PROPELLANT MIXING COMPARISON

## Propellant and Materials at Each Site

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A startling difference in temperature control capability which is an attribute of the production mixing process is shown on this chart. For continuous process, temperatures can be rapidly adjusted, whereas portions of the batch mix cycle are prolonged by the inability to rapidly cool or remove mixing heat during processing.



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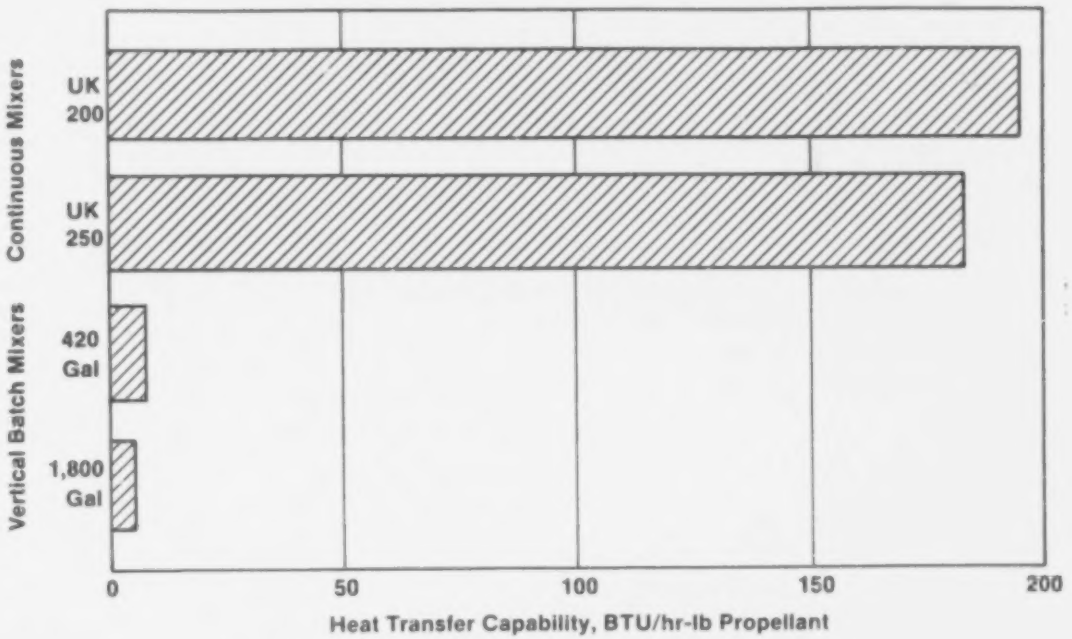
# SHUTTLE MOTOR MIXING COMPARISON

## Mixer Heat Transfer Capability

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**The conclusions presented are a further summary of the previous charts and emphasize that continuous processing offers reduced land requirements, operating personnel, and increased safety through reduction in explosive ingredient mass being mechanically mixed.**

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# PROPELLANT PROCESSING STUDY

## Conclusions

- The Only Demonstrated Production Propellant Mix Systems are the Continuous (Aerojet) and the Vertical Batch Mix 420-Gal
- The Other Continuous and Batch Mixing Systems are Feasible and Not Considered High Risk for Shuttle Propellant, But They are Not Demonstrated Systems
- Continuous Processing Reduces the Amount (400 vs 27,000 lbs) of Propellant Exposed to Mechanical Ignition Thus Reducing the Q-D Land Requirements (18 Acres vs 83 Acres)
- Continuous Processing Reduced the Manning Requirements by at Least 37.5%



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**Investment costs for minimum capability are presented for a variety of mix complex possibilities. As a point of reference, the new Hercules complex which includes only 2 to 1800 Gal VBMs, but is highly automated and includes casting, is reported to have cost $150M or nearly three times the minimum estimated cost.**



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# INVESTMENT INFORMATION

## Shuttle Motor Propellant Mixing Comparison

**9,000 lb/hr Max. Rate Required for 3 Segments/5 Day Wk; 36,000,000 lb Mixed/yr, Rate**

| | Continuous Mixing | | Batch Vertical Mixers | | | |
|---|---|---|---|---|---|---|
| | 1-UK 250 | 2-UK 200 | 3-1,800 Gal | 4-1,000 Gal | 5-600 Gal | 8-420 Gal |
| Land, Improved $10,000/Acre, $K | 90 | 150 | 240 | 300 | 360 | 450 |
| Mix Stations and Control Bldg, $K | 10,300 | 12,500 | 47,700 | 44,800 | 41,300 | 40,000 |
| Mix/Transport Bowls, $K | 2,700 | 2,700 | 3,300 | 3,100 | 2,800 | 2,700 |
| Premix Transport, $K | 200 | 200 | — | — | — | — |
| Oxidizer Transport Containers, $K | 50 | 50 | 50 | 50 | 50 | 50 |
| Total Mix Complex Investment, $K | 13,340 | 15,600 | 51,290 | 48,250 | 44,510 | 53,200 |

**Conclusions:**

- **Investment For Continuous Process is One-third of That For Batch Mix Process ($30 Million Dollars Less)**
- **A 30% Reduction in the Batch Mix Investment Could Be Achieved By Reducing the Batch Mix Cycle (Elimination of Redundant System Checks and "Interim" Mix Time)**



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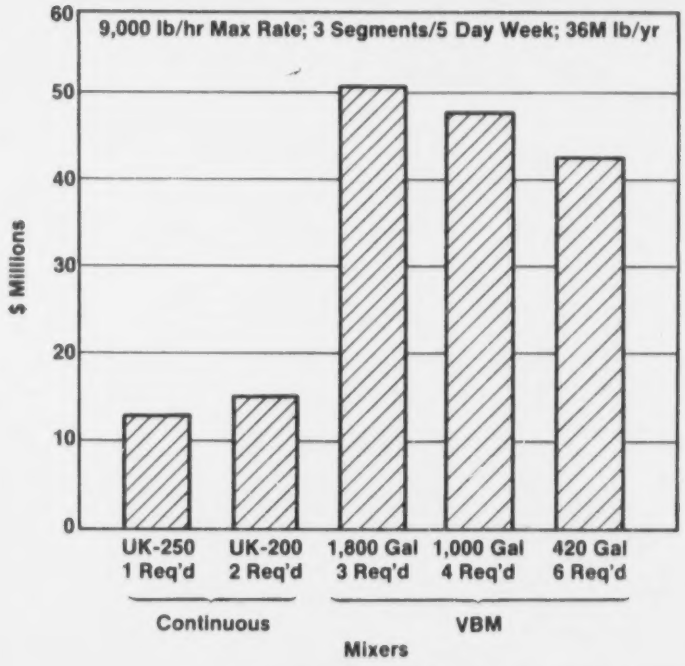
# SHUTTLE MOTOR PROPELLANT MIXING

## Investment Cost — Conservative Operation

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**Comparative Operating Cost/yr for Propellant are presented. The significant impact is that (1) continuous processing reduces operating labor costs and investment related costs (depreciation and maintenance) and (2) increasing the size of the batch mixer leads to little if any manufacturing cost reduction in batch processing since increased depreciation and maintenance is as large as the reduction in operating labor.**



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# PROPELLANT MIXING COST, $K/YEAR

## Shuttle Motor Propellant Production Comparison

**9,000 lb/hr Max. Rate Required for 3 Segments/5 Day Wk; 36,000,000 lb Mixed/yr**

| | Continuous Mixing | | Batch Vertical Mixers | | | |
|---|---|---|---|---|---|---|
| | 1-UK 250 | 2-UK 200 | 3-1,800 Gal | 4-1,000 Gal | 5-600 Gal | 6-420 Gal |
| Mixing Labor (Direct + Benefits) | | | | | | |
| Engineer (1/Day) | 60 | 60 | 60 | 60 | 60 | 60 |
| Foreman (3/Day) | 150 | 150 | 150 | 150 | 150 | 150 |
| Operators | 360 | 600 | 960 | 1,200 | 1,400 | 1,800 |
| | 570 | 812 | 1,170 | 1,410 | 1,650 | 2,010 |
| Power Cost at $0.06/kw-hr | 37 | 64 | 201 | 153 | 86 | 77 |
| Steam Cost at $3/1,000 lb Steam | 1 | 1 | 2 | 2 | 2 | 2 |
| Depreciation at 10% yr | 1,334 | 1,560 | 5,129 | 4,825 | 4,451 | 4,320 |
| Maintenance at 3% yr | 400 | 468 | 1,539 | 1,448 | 1,335 | 1,269 |
| Operating Cost (Less Materials) Sub Total | 2,342 | 2,903 | 8,041 | 7,838 | 7,524 | 7,705 |
| Raw Materials Cost | 51,246 | 51,246 | 51,246 | 51,246 | 51,246 | 51,246 |
| G&A 25% of Operating Cost | 586 | 726 | 2,010 | 1,960 | 1,881 | 1,926 |
| Profit 15% of investment | 2,001 | 2,340 | 7,694 | 7,238 | 6,677 | 6,480 |
| Sales Costs | 300 | 300 | 300 | 300 | 300 | 300 |
| Total Cost to Customer (Less Materials) | 5,229 | 6,269 | 18,045 | 17,336 | 16,382 | 16,411 |



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**These effects are shown visually in the bar chart on total yearly propellant manufacturing costs.**



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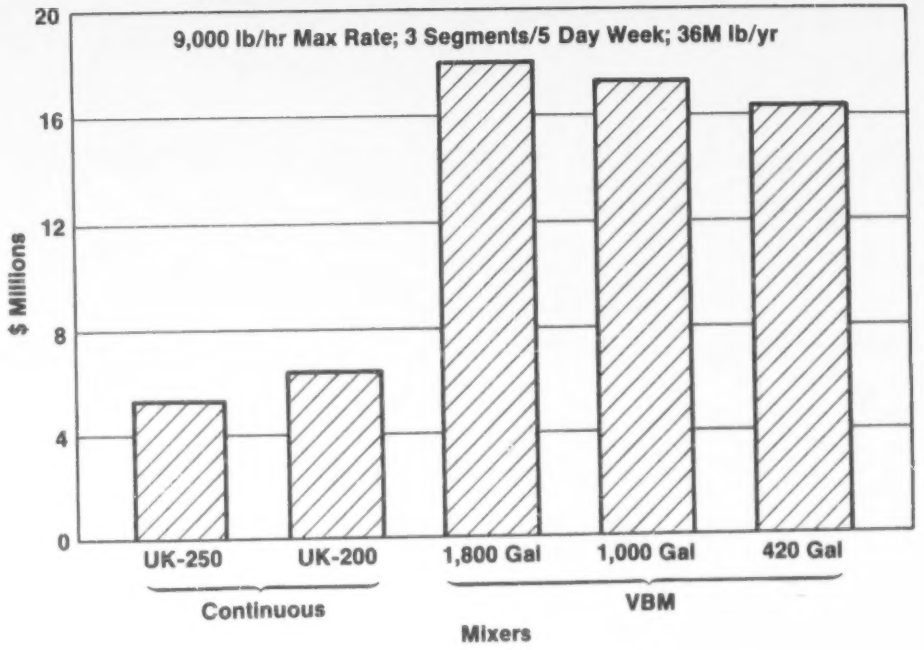
# SHUTTLE MOTOR PROPELLANT MIXING

## Operating Cost Per Year – Conservative

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87124-22

85171/6400/1194

**This chart emphasizes the personnel difference between batch and continuous processing.**



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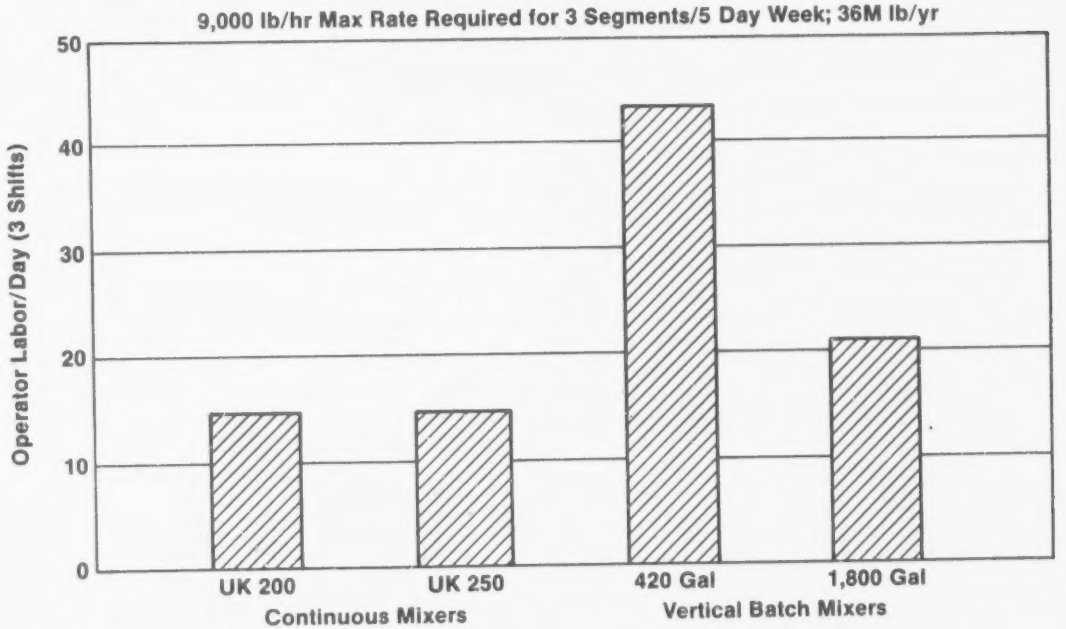
# SHUTTLE MOTOR PROPELLANT MIXING COMPARISON

## Personnel Required

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**This chart provides not only a cost component comparison but also represents a potential safety consideration in that the mixing HP and energy input for ignition under some failure conditions is extremely high in the 400 HP driven 1800 gallon mixers.**



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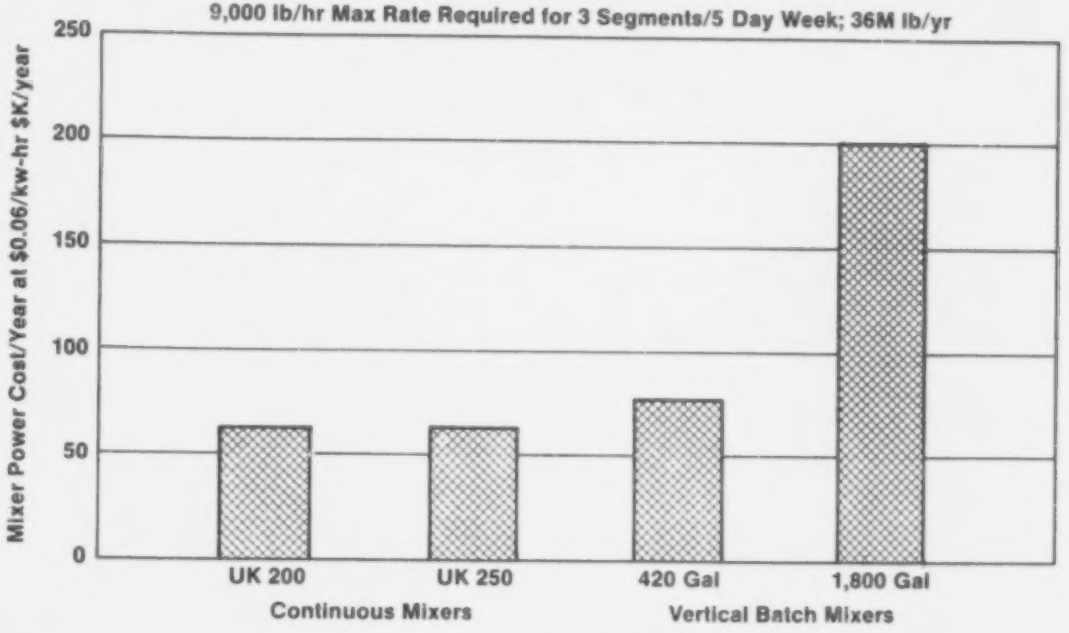
# SHUTTLE MOTOR PROPELLANT MIXING COMPARISON

## Power Cost/Yr

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Analysis of the Manufacturing cost leads to the conclusions enumerated here:

- The continuous mix process is the most cost effective, proven process for the high production rate required to load large booster rockets
- Raw materials are a significant manufacturing cost factor which must be given increased attention at each operational step from initial negotiated purchase, through loses, sampling, qualification frequency, and propellant testing to maximize the yield of ingredients in the delivered product
- The use of a new generation of very large batch mixers doesn't appear to be economically justified except in special cases where it is deemed necessary and feasible to cast an entire rocket grain from a single batch mix.



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# STUDY RESULTS
# CONTINUOUS PROPELLANT MIXING

## Conclusions

- The Most Attractive Shuttle Propellant Production Process is the Proven Aerojet Continuous Mix Process
- Continuous Mixing of Propellant For Shuttle and Other Process Improvements Will Save NASA $1,500,000/Flight Set Versus Prior ASPC Batch Mixing Estimate
- Every Effort Should be Made to Minimize the Cost of Raw Materials (Purchasing, Shipping, Scrap, Samples, Lot Size, Etc.) Since Ingredients Are Such a Large Part of the Operational Cost
- Propellant Mixing Costs For Continuous Process are One-Third The Cost of Batch Processing
- Use of Unproven 1,800-Gallon or 1,000-Gallon Mixers Will Not Substantially Reduce the Propellant Cost to the Customer From the Present 420-Gallon VBM Process



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A substantial portion of manufacturing process investment is nearly independent of the propellant mixing process. Conventional proven processing methods for much of the propellant support type facilities and tooling are listed in this figure. Any improvement made would apply for either batch or continuous propellant processing. The one area in the list which could be influenced by the propellant mixing process selected is transport to propellant casting where direct pipeline transport could be advantageously used for continuous mixing as opposed to conventional batch container transport.



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Mr. NELSON. Thank you, Mr. Brown.

Mr. Crosby?

Mr. CROSBY. Thank you, Mr. Chairman, distinguished members of the committee. In response to your request, I will keep my comments very brief. I would like to have my complete statement entered into the record.

I'll get to the bottom line first by saying that we, at United Technologies, are in complete accord and support with the NASA recommendation that has been made. And I'd like to say that for the most part we are in very considerable agreement with the arguments that Mr. Brown has just stated in support of that activity.

The key points I would just like to mention very briefly again are the fact that the redesigned Shuttle boosters do result in a rather severe performance penalty relative to the original design requirements. This, as we are all thoroughly familiar with, is a result of the need for considerable reliability improvements in the design, not only of the solids, by the way, but throughout the Orbiter system. The result of that is, without going into specific numbers, a very substantial payload degradation—payload capability degradation which limits the utility of the vehicle for the purposes for which it was originally intended. So for that reason, we strongly feel that a redesigned solid rocket should be undertaken. In an activity to develop such a motor, we believe that we can regain at least the lost performance in the current booster and probably provide a substantial performance increase.

The other point that was also made is that we also feel that the launch rate of the Space Shuttle in the future will be considerably below what the earlier projections were. We have taken action in the country to develop and put in place an expendable launch vehicle fleet. A very prudent action; we're in complete accord with it. As a result, we do not anticipate the very high launch rates that at one time seemed to thoroughly justify second source activity, so we question the economic viability of a second source program.

We particularly question the economic viability in a technical sense of a program to compete for the current booster which is inadequate in its basic design. If the use rate of those, of an advanced design booster, were such that it would justify having multiple sources, we would certainly support that activity and there are a number of ways that that could be approached, not the least of which is the possibility of annual, biennial, triennial competition to operate a government-owned facility that was emplaced and ideally configured to produce the advanced design boosters at the lowest possible price. So, in essence, we are—we are in complete support.

If I may, to get a few different words here, I'd like to—I ran across a letter to the editor in a recent Aviation Week as I was flying across the country and I think it expresses, perhaps, very well, and I'll just read out of context. But, if I may, it says:

> If we are going to have a viable space program we will have to commit ourselves to maintaining perpetually an assembly line in which a replacement vehicle is slowly being readied for the inevitable and where constant upgrading and refinement of existing vehicles as well as prototype manufacturing techniques are conducted.

Now, as I say, that is out of context, but I think the thought is there that if we're going to have a strong space program we can't

avoid the necessity of continually improving and upgrading the elements that make up that system. And for that reason alone, again, we are very much in support of the NASA program as recommended.

Thank you.

[The prepared statement of Mr. Crosby follows:]

STATEMENT OF HARRY L. CROSBY, VICE PRESIDENT,
BUSINESS DEVELOPMENT, CHEMICAL SYSTEMS DIVISION
UNITED TECHNOLOGIES CORPORATION
BEFORE THE SPACE SCIENCE AND APPLICATIONS SUBCOMMITTEE
OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

MAY 6, 1987

Mr. Chairman and distinguished members of the Subcommittee, thank you for this opportunity to provide the subcommittee with views on the space shuttle Solid Rocket Motor (SRM) acquisition plan submitted to you by NASA on March 31, 1987. We have reviewed the NASA plan not only from the standpoint of how the plan would affect United Technologies business and how we could participate in the program, but also from the position of concerned citizens and what we believe are the important national issues associated with the Space Shuttle program.

Without reservation, United Technologies fully supports the NASA SRM acquisition plan as presented because it correctly addresses issues of national importance that must be resolved to ensure that this nation will have a strong and viable manned space launch capability through the 1990's and into the next century. We believe that the critical issues related to the SRM's are frequently overshadowed by the emotional reaction against Morton Thiokol because of the Challenger mission 51-L tragedy, and we appreciate this opportunity to express our views on this subject.

As a result of the Challanger incident, the nation is in the midst of a launch capability crisis. Resolution of this crisis has led to the following actions:

1. A decision has been made and implemented to acquire a mixed expendable launch vehicle fleet that can handle a range of military and commercial payloads up to and including many that could previously only be assigned to the space shuttle. We believe this step is most prudent for protection of future space launch capability. We also recognize that this decision will reduce the mission requirements for the shuttle and therefore both the rate of production and total quantity of shuttle boosters required is significantly reduced, particularly in the early years after the resumption of flights.

2. The MTI/NASA shuttle booster SRM is undergoing an extensive redesign and requalification program. At the same time other subsystems of the orbiter, the main engines (SSME) and the expendable tank (ET) are being re-examined, modified and requalified. The combined effects of these actions will be to provide increased reliability and safety as well as to establish operational limits (for example a 104% limit on SSME operation) that are absolutely necessary before the shuttle begins to fly again. An unfortunate byproduct of

these necessary redesign actions will be significant losses in payload performance. While NASA is still developing performance estimates and refining payload limitations, margins and reserves, it is apparent that the original ascent performance from Kennedy Space Center has been reduced by 6000 pounds or more and the polar orbit capability from Vandenberg is down by approximately 7500 pounds or more.

brief, the impact of Challenger and the resulting reevaluation d redesign of many of the shuttle's subsystems is a stretch out the scheduling of flights, a reduced requirement for booster cket motors in the early years after resumption of flights, and critical need for an improved booster motor to regain the gnificant loss in payload capability. An improved booster will so provide higher margins of reliability and safety for future nned missions than can be achieved with the current redesigned M.

ited Technologies believes that conducting a competition now for second source of the current redesigned SRM is economically sound and does not address the real needs of the shuttle program d of the nation's manned space flight capability. At the same me, we are convinced that an advanced solid rocket motor (ASRM) r NASA's announced plan can be developed and ready for operation 1993 or earlier. This ASRM will fully restore the original anned payload capability of the shuttle and will do so with gher margins of safety and reliability than can be achieved with e redesigned SRM. Therefore, we strongly urge your committee to pport the plan that has been recommended by NASA as follows:

1. Begin the Phase B definition studies of an improved solid motor (the ASRM) as soon as possible.

2. Continue the Morton Thiokol program to redesign and requalify the current boosters in order to achieve the earliest possible flight capability for national priority missions and payloads. The 13 flight sets of boosters currently on order will support the resumed flight program past the point where a decision must be made on full scale development of an advanced SRM. Thus, a buy out decision on the existing SRM's can be made in the future in conjunction and accordance with a full scale development decision on the ASRM.

or all the reasons stated, and because it is a realistic and ound approach for the nation, we urge your Committee to support ASA in the Space Shuttle Solid Rocket Motor Proposed Acquisition trategy and Plan presented on March 31, 1987.

Mr. NELSON. Mr. Biehler?

Mr. BIEHLER. Is the mike on?

Mr. Chairman, we appreciate the opportunity to meet with you today along with members of your subcommittee. My name is Bruce Biehler. I'm a Group Vice President with Hercules—excuse me—with Hercules, Incorporated. Dr. Ward Hill, who is here on my left, is the Manager of our NASA programs. I've asked him to provide the testimony to you this afternoon.

Mr. HILL. Mr. Chairman, we certainly—we certainly appreciate the opportunity to come before the subcommittee this afternoon and share with you our thoughts on this common national objective.

We feel that the current policy, that procurement policy is falling short, with regard to solid rocket motors. NASA currently has no management options and they are dependent on the resources and policies of its only contractor. NASA's long established practice of sole source procurement and contractor alliance has served them well previously in R&D-type of programs, but this is no longer appropriate today in an operational environment with a service-oriented program.

On the advanced solid rocket motor, we do believe that this could be an important part of a robust Shuttle program for the 1990s. We understand this payload deficit which has been related to exceeds 15,000 pounds under the current redesign program, and we know that there are many locked-in design features and processing features that were selected nearly 20 years ago and that these are very difficult to control to today's standards of reliability. However, we're sensitive to the fact that serious budgetary questions may bring into question whether an advanced program will survive the Administration and the congressional review.

The Shuttle probably cannot be displaced by a military heavy lift vehicle because the Air Force advanced launch system has different, and may be radically different approach to the management of cost and reliability issues to best serve their requirements. We believe we need a robust civil Shuttle in order to provide continuity and confidence to both national and international agencies while these new generation technologies are being developed.

The advanced rocket motor may be an effective path to a robust Shuttle, but we believe this competition should be accelerated in order to conserve and maximize the currently available funds that are available to start. Furthermore, we believe this acceleration is the only economical way to make the 1993 operational date and achieve both the desired goals of improved design and improved manufacturing technology. If these available funds are diluted, there will be much duplication of the trivial introductory-type of study effort and the delay in starting results in a duplication of facilities and in longer exposure to the redesigned Shuttle motor.

Now a strong, robust Shuttle is probably the least expensive Shuttle because cost must be considered in terms of the payload that's lifted; and, hence, poor performance is a major contributor to high cost. Most of the payload deficit is due to Orbiter issues, as you recognize that a pound of Orbiter payload—a pound of Orbiter weight is a pound of payload; whereas, a pound of solid rocket motor weight is only about a tenth of a pound of payload. But how-

ever, recovery of this performance is almost entirely invested in the solid rocket motor, which provides the only opportunity to do that.

Our studies have shown that the reliability goals of the advanced motor and the performance deficit can be recovered with an advanced rocket motor, and we believe the industry of this country is well prepared to supply services and products that would be required, if given a fair and equal opportunity to win. We will compete vigorously with any—within any format that makes economic sense.

Development costs for the advanced rocket motor are approximately $500 million—as has been noted before—using a segmented motor and meeting today's qualifications for reliability. We think this is significantly more for a one-piece case motor due to the additional testing needed to verify ballistic reproducibility and to related scale-up issues, and also to include the cost of restructuring the launch site facilities.

Production costs. Production costs for an advanced motor may be lower than the current redesign motor by the use of the modern technologies that we've been referring. We think $15 million per flight set is not an unreasonable goal, given a multi-year program at 16 flights per year using that type of technology, and $17 million could be achieved at 12 flights per year.

Any attempt to drive the cost upward by unnecessary restructuring of the system configuration or the capitalization procedures or Government investment in the incumbent's competitive position should be viewed with alarm as a means to undermine the competitive process and retain the status quo.

With regard to a second source for the redesigned motor, starting a competition now would give the agency the opportunity to have two contractors working on enhancement changes in the redesign that may be necessary, particularly if the advanced motor were not approved by the Administration and the Congress. NASA projects that even with the advanced motor it will purchase 74 motor sets from the incumbent between 1989 and 1995 for a total business base of 1.8 billion, and that certainly is attractive to a shared competition.

However, we believe the NASA cost analysis for this option is high and is based on incumbent data and requirements. Our analysis shows that on a 60–40 split the cost should be below 17 million for a flight rate of 16 per year, and about 18 million for 12 flights per year. This includes the refurbishment costs. If we were to use the Government-supplied refurbished hardware and materials, it would be about 12.5 million for 16 set and 13.5 for 12 sets per year.

However, a winner-take-all competition, as we noted previously, that the redesign sock—rocket motor is not yet certified for flight, and a winner-take-all competition could not be conducted without considerable risk to both NASA and the contractor until well after the flights had resumed and that eliminates most of the benefits of that approach.

In any case, this competition would be difficult for a new SRM contractor to win and would probably be viewed as a means to continue the status quo with the probability that creeping sole source

development with the incumbent is the objective, and we could not see that as an acceptable alternative.

So we believe that maintaining the status quo is a risky and expensive approach. We believe that's not acceptable because the incumbent retains control over the program and is awarded new development business without a fair and open competition.

And, Mr. Chairman, we are very concerned about the space program. We're very happy to be here today and have the opportunity to express these views.

[The prepared statement of Mr. Biehler follows:]

TESTIMONY OF BRUCE BIEHLER, GROUP VICE PRESIDENT, HERCULES AEROSPACE PRODUCTS GROUP, HERCULES INCORPORATED, BEFORE THE SPACE SUBCOMMITTEE OF THE HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON THE MATTER OF ALTERNATIVE PROCUREMENT STRATEGIES FOR THE SHUTTLE SOLID ROCKET MOTOR, MAY 6, 1987.

Mr. Chairman: We appreciate the opportunity to come before the Subcommittee this afternoon to share with you and the other members our views on a common National objective--a vibrant space program predicated on sound technical, managerial and cost criteria.

Current policy toward this end, in our view, falls short. With regard to the solid rocket motors, NASA has no management options, and is dependent on the resources and policies of its only contractor. NASA's long established practice of sole source procurement and contractor alliance, which served well in early R&D oriented programs, is no longer appropriate for operational, service oriented programs. The agency's hesitancy to commit to a second source reflects a lack of experience of the benefit of the competition process.

Development of an Advanced SRM (ASRM) could be a keystone to a robust Shuttle program in the 1990's. The payload deficit now exceeds 15,000 pounds under the redesign program. Also, locked-in design and processing features that were selected nearly 20 years ago now require extraordinary oversight to control today's standards of reliability. Serious budgetary questions, however, bring into question whether an ASRM program will survive Administration and Congressional review.

We do not believe the Shuttle can be displaced by a military heavy lift vehicle. The Air Force Advanced Launch System (ALS) is equally essential, but has different goals and objectives. The ALS may be radically different in approach to management of cost and reliability issues to best serve military requirements. A robust civil shuttle is needed to provide continuity and confidence to national and international agencies as new generation technologies are developed.

With regard to the development of an Advanced Solid Rocket Motor, the ASRM is an effective path to a robust shuttle, but the competition must be accelerated to conserve and maximize benefit from current $20 million fund. Furthermore, acceleration is the only economical way to make the 1993 operational date and achieve desired goals of improved design and new manufacturing technology. Dilution of available funds will result in duplication of trivial introductory effort; delay in starting results in duplication of facilities and longer exposure to the Redesigned SRM.

A robust shuttle is the least expensive shuttle. Cost must be considered in terms of payload lifted, hence poor performance is a major contributer to high cost. While payload deficit is mostly due to orbiter issues, recovery of capability is vested almost entirely in SRM performance.

The highest cost of all is failure, and while the current redesign may be "safe to fly" when properly requalified and watched during manufacture, the solutions that were available under the constraints of the national emergency do not eliminate limitations of the technologies that were present prior to the Challenger failure.

Our studies show the reliability goals of ASRM can be met and also recover most of the performance deficit (15,000 lb.).

But we understand there is a question whether the Congress and the Administration are willing to commit $500 million to this effort in view of the limited payload prospects for the Shuttle.

The industry of this Country is well prepared to supply the services and products desired, and if given a fair and equal opportunity to win, will compete vigorously within any format that makes economic sense.

Development costs for ASRM are approximately $500 million for a segmented motor using today's qualification standards, significantly more for a one-piece case motor due to the additional testing needed to verify ballistic reproducibility and related scale-up issues, and the enormous cost of restructuring the launch site facilities.

Production costs for ASRM may be reduced from the RSRM by the application of modern manufacturing technology. $15 million per flight set is not an unreasonable goal given a multi-year program at 16 flights per year from such a facility, and $17 million could be achieved at 12 flights per year.

Any attempt to drive the cost upward by insertion of unnecessary restructuring of the system configuration or normal capitalization procedures or government investment in the incumbent's competitive position should be viewed with alarm as a means to undermine the competitive process and retain the status quo.

With regard to a second source for the redesigned motor, starting a competition now would give the agency the opportunity to have two contrators working on any enhancement changes in the redesign that may become necessary, particularly if ASRM were not approved by the Administration and the Congress.

NASA projects that even with the ASRM, it will purchase 74 motor sets from the incumbent between 1989 and 1995 for a total business base of $1.8 billion.

We believe the NASA cost analysis for this option is high and is based on incumbent data and requirements. Our analysis shows that on a 60/40 split the cost should be below $17 million for a flight rate of 16 per year and about $18 million for 12 flights per year. This price includes refurbishment. Hercules' cost with reusable government furnished materials, would be $12.5 million for 16 sets and $13.5 million for 12 sets.

With regard to a winner take all competition, as noted above, the RSRM is not now certified for flight. A winner take all competition could not be conducted without risk to both NASA and contractor until well after flights had resumed, thereby eliminating any benefits.

In any case, this type of competition would be difficult for a new SRM contractor to win, and would merely be viewed as a means to continue the status quo, with the probability that creeping sole source development with the incumbent is the objective. We cannot see this as an acceptable alternative.

Maintaining the status quo is risky and expensive. We believe this is not acceptable because the incumbent retains control over the program and is awarded new development business without fair and open competition, an issue that should be of concern to the agency and this committee.

Mr. Chairman, Hercules is deeply concerned about the future of the space program and we thank the committee for the opportunity to present these comments.

Mr. NELSON. Thank you, Mr. Hill.

Mr. Sides?

Mr. SIDES. Mr. Chairman, committee members, colleagues, and ladies and gentlemen: I appreciate the opportunity to present Atlantic Research Corporation's views on the Space Shuttle solid rocket motor procurement strategy.

My name is James Sides. I'm the President of the ARC Group of Atlantic Research Corporation. My organization is headquartered close by in Alexandria, Virginia, with facilities in Gainesville, Virginia, and Camden, Arkansas. Our solid propellant production plant in Camden, Arkansas, currently manufactures composite solid propellants at a rate equivalent to approximately nine Shuttle SRM flights per year. We believe we are currently producing at the highest volume rate of any company in the free world.

ARC favors both of the first two options that were discussed in your letter, Mr. Chairman. We believe that an advanced solid rocket motor and a competition of the redesigned SRM need not be mutually exclusive. We endorse NASA's acquisition plan for an ASRM starting with Phase B studies. In addition, we believe that NASA should prepare for competition of the redesigned SRM if they're unable to proceed with the ASRM.

Phase B contractors should be requested to provide cost estimates for qualification and production of the redesigned SRM on a follower basis, and I'll talk more about that in a minute. These cost estimates should be provided to NASA along with ASRM costs so that this competition option is available if NASA is unable to secure funding for the advanced solid rocket motor development.

We believe that the winner-take-all competition for the redesigned motor and the "maintain the status quo" options are, for all practical purposes, identical since, has previously been pointed out, the incumbent contractor has such large advantages that it's an insurmountable advantage to overcome. A winner-take-all competition is not in the Government's best interest since it maintains a single production source for the future. Production under continuing competition will assure the best quality, most reliable, lowest cost Shuttle SRM, as well as maintaining a parallel industrial base.

This hearing, Mr. Chairman, represents Atlantic Research Corporation's third opportunity in the last 10 months to express before Congress our interest in resolving America's space crisis by means of American teamwork. On the 31st of July last year, before the Government Operations Committee of the House of Representatives—Mr. Brooks' committee—and on January 22nd of this year before the Senate Commerce Committee, I stated that ARC considers the Space Shuttle's safe return to flight a national issue and that the SRM recovery could be most effectively resolved by industry teamwork. I further suggested a consideration of competition through a leader/follower approach.

My company presented a number of ideas for an improved solid rocket motor in our Block II study including a bolted flange field joint and an improved performance, non-asbestos-containing insulation. We further offered an unsolicited proposal to the Solid Rocket Motor Redesign Team at NASA Marshall for a subscale motor test effort to demonstrate these concepts and provide an alternate for the SRM redesign.

We understand that NASA had Morton Thiokol initiate a subscale motor insulation test effort and is considering a bolted flange alternate design and test program at the same contractor. While we're disappointed that Atlantic Research was not selected to participate, we are fully supportive of this effort and encourage NASA to continue. We believe that this validates the benefits of any continuing recommendations for a team approach to the SRM recovery. We believe that increased industry participation will result in the safest and fastest return to flight status. We believe that this industry participation should be followed by a competition on a leader/follower basis for the advanced solid rocket motor or, alternatively, the redesigned SRM if the advanced SRM is not funded.

What we would like your committee and the Congress to consider, Mr. Chairman, in regard to establishing two sources for the SRM, is an acquisition strategy similar to a recent DOD innovation. Contractor teams would jointly develop the advanced solid rocket motor on a cooperative basis. Both members of the winning team would then be qualified to competitively produce the final design. This approach assures a broad technical base, separate production facilities, and built-in competition.

Alternatively, if NASA is unable to secure funding for the ASRM, we recommend that NASA select a follower contractor, structure the incumbent contractor's production contract for motivation to help the follower qualify, and prepare for production competition.

We, I would like to comment briefly on the issue of the GOCO—government-owned, contractor-operated—facility. We understand that NASA wants Phase B contractors to study facilities and processes on both a company- and government-owned facility, and that's a reasonable request. We have visited the NASA Mississippi NSTL facility and believe that a GOCO facility there or elsewhere would be more expensive to the program than improvements to our current existing Camden, Arkansas facility.

In summary, ARC believes that the advanced solid rocket motor and second source are not incompatible. NASA should initiate an alternative second source option in the event ASRM funding cannot be secured. We believe a leader/follower acquisition approach is attractive for either ASRM or a recovery SRM. And we very much encourage NASA to involve industry more actively in the ongoing recovery program.

Thank you, Mr. Chairman. I'd be glad to address the questions, any further questions you may have or members of your committee.

[The prepared statement of Mr. Sides follows:]

Testimony of Mr. James R. Sides, Group President of the ARC Group and General Manager of the Propulsion Division of Atlantic Research Corporation before the Subcommittee on Space Science and Applications of the Committee on Science, Space, and Technology of the United States House of Representatives, Washington, D.C., Wednesday, May 6, 1987.

Mr. Chairman, Committee Members, Colleagues, Ladies and Gentlemen:

Thank you for the opportunity to present Atlantic Research Corporation's views on Space Shuttle Solid Rocket Motor procurement strategy.

I am James R. Sides, Group President, ARC Group of the Atlantic Research Corportion. My organization is based in Alexandria and Gainesville, VA, and Camden, Arkansas. Our plant in Camden, Arkansas, currently manufactures composites solid propellants at a rate equivalent to nine Shuttle SRM flights per year.

ARC favors both of the first two options discussed in your letter, Mr. Chairman. We believe that an Advanced Solid Rocket Motor (ASRM) and competition of the redesigned SRM need not be mutually exclusive. We endorse NASA's Acquisition Plan for an ASRM starting with Phase B Studies. In addition, we believe that NASA should prepare for competition of the redesigned SRM if they are unable to proceed with the ASRM. Phase B contractors should be requested to provide cost estimates for qualification and production of the redesigned SRM on a Follower basis. These cost estimates should be provided to NASA along with ASRM costs so that this competition option is available if NASA is unable to secure funding for ASRM Development.

ARC believes that the "winner take all" competition for the redesigned motor and the "maintain status quo" options are, for all practical purposes, identical since the incumbent contractor has such large advantages. A "winner take all" competition is not in the government's best interest since it maintains a single production source for the future. Production under continuing competition will assure the best quality, most reliable, lowest cost Shuttle SRM as well as maintaining a parallel industrial base.

This hearing, Mr. Chairman, represents Atlantic Research Corporation's third opportunity in the last ten months to express before the Congress our interest in resolving America's space crisis by means of American teamwork. On July 31 last year, before the Government Operations Committee of the House of Representatives, and on January 22 this year, before the Senate Commerce Committee, I stated that ARC considers the Space Shuttle's safe return to flight a National Issue and that SRM recovery could be most effectively resolved by industry teamwork. I further suggested a consideration of competition through a Leader-Follower approach.

ARC presented a number of ideas for an improved SRM in our Block II study including a Bolted Flange Field Joint and improved performance, non-asbestos insulation. We further offered an unsolicited proposal to the SRM Redesign team at NASA Marshall Space Flight Center for a subscale motor test effort to demonstrate these concepts and provide an alternate for the SRM redesign. We understand that NASA has had Morton Thiokol initiate a subscale motor insulation test effort and a Bolted Flange alternate design and test program. While we're disappointed that ARC was not selected to participate, we are fully supportive of this effort and encourage NASA to continue. We believe that this validates the benefits of any continuing recommendations for a team approach to SRM recovery. We believe that increased industry participation will result in the safest and fastest return to flight status. We believe that this industry participation should be followed by competition on a Leader-Follower basis for the ASRM or, alternatively, the redesigned SRM if the ASRM is not funded.

What we would like your Committee and the Congress to consider in regard to establishing two sources for the SRM is an acquisition strategy similar to a recent Department of Defense innovation. Contractor teams would jointly develop the ASRM on a cooperative basis. Both members of the winning team would then be qualified to competitively produce the final design. This approach assures a broad technical base, separate production facilities, and built-in competition. Alternatively, if NASA is unable to secure funding for the ASRM, we recommend that NASA select a Follower contractor, structure Morton Thiokol's production contract for motivation to help the Follower qualify and prepare for production competition.

Mr. Chairman, we have prepared cost estimates for qualification and production of the current redesigned SRM in response to your request. We estimate the cost of Qualification to be less than $150 Million. Production units are estimated at $15 Million per flight for 12 flights per year and $14.5 Million per flight for 16 flights per year.

Thank you, Mr. Chairman. I would be glad to address the questions of costs, safety, and any others you have, as well as questions from those of any Member of your Committee.

Mr. NELSON. Thank you, Mr. Sides.

Mr. Thirkill?

Mr. THIRKILL. Thank you, Mr. Chairman, members of the committee.

I'm John Thirkill, Vice President and General Manager of the Space Division of Morton Thiokol, and we're located in Brigham City, Utah. I am pleased to appear before the committee to present testimony regarding NASA's acquisition strategy and plan for the Space Shuttle solid rocket motors.

I have a prepared statement, which I would like to submit for the record and, with your permission, would like to summarize it right now. Before addressing the specifics of NASA's plan I would like to provide a very brief assessment of our activity on the redesign effort which I feel is relevant to today's hearings.

I'd like to take this opportunity to re-emphasize our understanding that success is mandatory in this effort. We, at the Space Division, and throughout Morton Thiokol, have no higher commitment, and we are dedicated to ensuring reliable and safe operation of the Space Shuttle. Both our facilities and staffing have expanded to expedite the recovery schedule, but more importantly, to assure that the Space Shuttle safely returns to flight.

An example is the second static test facility which will be completed in October of this year. In response to the Rogers Commission recommendations, this test stand adds the capability to apply external flight loads during a motor firing to better simulate flight conditions.

We have made significant progress and are confident that we shall successfully accomplish a redesign and test program which fully supports NASA's objectives and requirements. Significant attention has been given to the SRM field joint and nozzle-to-case joint. Backup and contingency joint designs are being pursued in addition to the primary redesign approach. However, all areas of the SRM design have been assessed and other significant design changes have been made in the nozzle, with minor changes to the igniter and propellant configuration.

The first of a series of full duration SRM static tests is scheduled for later this month. This engineering test motor will be followed by five development and qualification static tests to verify that the redesigned SRM meets all specification requirements. This work has received detailed review by NASA's Design Review Committee and by the National Research Council Panel for the Technical Evaluation of the Redesign of the Space Shuttle Solid Rocket Booster. We are convinced that this program will deliver solid rocket motors that meet all safety and operational goals for the Space Shuttle. The completion of the redesigned SRM program will result in a flight motor of unprecedented reliability.

Competition for the redesigned SRM is addressed in NASA's recently announced acquisition strategy and plan for the Space Shuttle solid rocket motor. In preparing the acquisition strategy and plan NASA evaluated the results of Block II SRM concept studies by the five major solid rocket motor contractors including ourselves. NASA reached the following two conclusions from these studies:

One—the new design concepts presented by the industry would not result in major improvements in flight safety and reliability; however, both would be enhanced; and, second, the new design concepts offered by the industry could significantly increase system performance.

NASA also noted that a substantial data base development is required to establish the feasibility and reliability for many of the concepts, such as the large monolithic propellant grain configuration or a change to a new propellant formulation. Significant expenditures will be required to assure that the advanced solid rocket motor provides the desired performance improvements while maintaining SRM safety and reliability.

Subsequently, NASA announced its intent to release an RFP for multiple Phase B studies of an advanced solid rocket motor which would address issues of increased reliability and performance. The Phase B studies would more completely evaluate both monolithic and segmented propellant grain configurations and would adequately assess the overall impact of a modern automated SRM production facility on motor cost and quality.

Morton Thiokol fully supports NASA's acquisition plan, which contemplates a decision being made at the end of Phase B whether to proceed into the Phase C/D development and qualification program. The Phase B effort will allow each of the contractors to complete detailed definition of advanced solid rocket motor concepts before entering a major advanced design and development activity. Phase B studies will also define the necessary development and qualification effort to assure that new advanced SRM designs and manufacturing processes will satisfy all flight safety and reliability requirements.

NASA considered developing a second source for the redesigned solid rocket motor. Development of a second source increases overall program costs, as evidenced by data NASA recently provided to the committee, and I believe as confirmed here today by testimony of my cohorts. This cost increase results from a number of factors: (1) splitting the already low production rate, thus increasing the cost for each supplier; (2) the high cost of qualifying an alternate source; and (3) the additional tooling and facility cost which must be recovered by the alternate source.

Our facility presently has the capacity to produce up to 26 flight sets per year. With a reduction in the flight rate, our facility will be operating at approximately 50 percent of its capacity. A split production between two sources would lower that further. It is difficult to offset the effect of a lower production rate for a product such as the SRM. Approximately a third of the recurring costs are in basic materials and components which are supplied by the same industry sources to all SRM contractors, and half of the labor costs are mandated support costs.

We believe NASA's decision not to pursue a second source for the redesigned SRM is well-founded on economic grounds. It is important to resist the temptation to accept at face value the comparison of actual SRM production costs to costs that are estimated without actual experience of satisfying NASA's manned space flight requirements.

It should also be noted that the projected economies are based on facilities that are not yet constructed or facilities that are yet to deliver a production motor.

In conclusion, Mr. Chairman, I believe we all share the same objectives: return the Shuttle to safe flight; and provide the Nation with a reliable, efficient and cost-effective solid rocket motor. We believe NASA's acquisition strategy is in the Nation's best interest. It provides the most efficient, cost-effective and safest approach and does so without jeopardizing the current Shuttle program or introducing additional risk.

Mr. Chairman, I appreciate the opportunity to testify on this very important subject and will be pleased to answer any questions the committee may have. Thank you.

[The prepared statement of Mr. Thirkill follows:]

STATEMENT

OF

MR. JOHN D. THIRKILL

VICE PRESIDENT AND GENERAL MANAGER, SPACE DIVISION

MORTON THIOKOL, INCORPORATED

WASATCH OPERATIONS

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

May 6, 1987

Mr. Chairman and members of the Committee:

I am John Thirkill, Vice President and General Manager of the Space Division of Morton Thiokol, Inc., located in Brigham City, Utah. I am pleased to appear before the Committee to present testimony regarding NASA's acquisition strategy and plan for Space Shuttle Solid Rocket Motors. That plan, released on March 31, 1987, was developed by NASA to outline a comprehensive strategy for continued procurement of SRMs for the Space Shuttle program. It addresses potential

modified designs for the SRM, alternatives for future procurement, and the costs and benefits of each alternative.

Before addressing the specifics of the plan, however, I would like to provide a brief assessment of our redesign effort which I feel is relevant to today's hearings. Morton Thiokol's qualification of the redesigned solid rocket motor (RSRM) to support the resumption of Space Shuttle flights in 1988 is an integral part of the acquisition plan. Let me take this opportunity to reemphasize our understanding that success is mandatory in this effort. We have no higher commitment, and we are dedicated to ensuring reliable and safe operation of the Space Shuttle.

Morton Thiokol's Space Division is organized to accomplish the redesign, qualification, and return to flight. Our facility in Utah is equipped to support all aspects of SRM design, manufacture, and testing. These facilities are dedicated solely to the production of the highest quality SRM components and represent a replacement value of over $400 million. In addition to the facilities, we have tooling and equipment in excess of $100 million employed in SRM production. We are organized and staffed with dedicated capabilities in Management; Safety, Reliability and Quality Assurance; Manufacturing Operations; Engineering; and Test. Both our facilities and staffing have expanded to expedite the recovery schedule, but more importantly, to make certain that the Space Shuttle safely returns to flight. An example is the second static test facility which will be completed in October of this

year. In response to the Rogers Commission recommendations, this test stand adds the capability to apply external loads during a motor firing to better simulate flight conditions. In order to provide further information concerning Morton Thiokol's activities regarding the SRM program I have included a copy of the testimony submitted by my predecessor, Mr. Edward G. Dorsey, to the House Government Operation Committee last July 31, 1986.

We have made significant progress and are confident that we shall successfully accomplish a redesign and test program which fully supports NASA's objectives and requirements.

A complete evaluation of the SRM has addressed the design, manufacturing process, verification and acceptance procedures, operating environment, assembly and system requirements. Significant attention has been given to the SRM field joint and nozzle-to-case joint. Backup and contingency joint designs are being pursued in addition to the primary redesign approach. However, all areas of the SRM design have been assessed and other significant design changes have been made in the nozzle, with minor changes to the igniter and propellant configuration. This work has received detailed review by NASA's Design Review Committee and by the National Research Council Panel for the Technical Evaluation of the Redesign of the Space Shuttle Solid Rocket Booster.

A comprehensive test program, including work from laboratory tests to full scale, full duration rocket motor

static firings, has been defined and reviewed with NASA and the NRC. Substantial testing has been accomplished in new specialized test stands for short duration full scale static firings of the Joint Environment Simulator and the Nozzle Joint Environment Simulator. These test articles utilize full scale components and are being employed to verify redesigned field and case-to-nozzle joints. In addition, work is progressing well on the Transient Pressure Test Article facility at NASA Marshall Space Flight Center where additional dynamic load simulation will accompany short duration full scale static firing tests. The first of the series of full duration SRM static tests is scheduled for later this month. This Engineering Test Motor will be followed by five development and qualification static tests to verify that the redesigned SRM meets the critical specification requirements. We are on schedule to support the next Space Shuttle flight.

We are convinced that this program will deliver solid rocket motors that meet all safety and operational goals for the Space Shuttle. This redesign builds on the manufacturing, flight and refurbishment experience derived from earlier Space Shuttle missions. The qualification test program will verify that the system is ready for flight. The intensity of the analyses, tests and review processes will ensure the integrity of the RSRM. The completion of the RSRM program will result in a flight motor of unprecedented reliability. Demonstration of the RSRM reliability will further accumulate as the flight rate builds.

This RSRM is a subject included in NASA's recently announced Acquisition Strategy and Plan for the Space Shuttle Solid Rocket Motor. In preparing the Acquisition Strategy and Plan, NASA also assessed the results of Block II SRM Concept Studies by the five major solid rocket motor contractors, including Morton Thiokol. These contractor studies covered design, program planning and cost issues for new SRM concepts, and also offered an opportunity for the industry to review and critique the redesign steps presently underway.

NASA reached the following two conclusions from these studies: (1) The new design concepts presented by the industry would not result in major improvements in flight safety and reliability; however, both would be enhanced; and (2) the new design concepts offered by the industry could significantly increase system performance. NASA also noted that a substantial data base development is required to establish the feasibility and reliability for many of the concepts, such as a large monolithic propellant grain configuration or a change to a new propellant formulation. Significant expenditures will be required to assure that the ASRM provides the desired performance improvements while maintaining SRM safety and reliability.

Subsequently, NASA announced its intent to release an RFP for multiple Phase B studies of an Advanced Solid Rocket Motor (ASRM) which would address issues of increased reliability and performance. The Phase B studies would more completely evaluate both monolithic and segmented propellant grain configurations, and would assess the overall impact of a

modern, automated SRM production facility on motor cost and quality. NASA concluded that, if performance or reliability enhancement could be economically achieved, it would then proceed into a development qualification program for an advanced motor design beginning in fiscal year 1989.

Morton Thiokol fully supports NASA's acquisition plan, which contemplates a decision being made at the end of Phase B whether to proceed into the Phase C/D development and qualification program. The Phase B effort will allow each of the contractors to complete detailed definition of ASRM concepts before entering a major advanced design and development effort. Phase B studies will also define the necessary development and qualification effort to assure that new ASRM designs and manufacturing processes will satisfy all flight safety and reliability requirements.

NASA considered developing a second source for the RSRM. Development of an alternative source increases overall program costs, as evidenced by data NASA recently provided to the Committee. This cost increase results from a number of factors: (1) splitting the already low production rate, thus increasing the cost for each supplier; (2) the high cost of qualifying an alternate source; and (3) the additional tooling and facility cost which must be recovered by the alternate source.

The Space Shuttle program presently has the capacity at our facility to produce up to 26 flight sets per year. We have routinely operated at production rates up to 12 flight

sets a year and have actually demonstrated propellant processing rates to produce in excess of 24 flight sets per year. With the reduction in the flight rate, our facility will be operating at approximately 50% of its capacity. Further, if a second source is established, its facility would likely be built to support at least 12 to 16 flights per year. Consequently, a split production between two sources would result in our facility operating at approximately 25% of its capacity and the second source's facility operating at less than 50% of its capacity.

In addition to the excessive idle facility capacity discussed above, the fixed costs of production and costs for management of a critical component for manned space flight would be spread over fewer delivered units at both contractors in a dual source procurement, thereby increasing unit costs. It is difficult to offset the effect of a lower production rate for a product such as the SRM. Approximately a third of the recurring costs are in basic materials and components which are supplied by the same industry sources to all SRM contractors and half of the labor costs are mandated support costs.

We believe NASA's decision not to pursue a second source for the RSRM is well founded on economic grounds. Any decision to proceed with a second source should be based on the real costs of establishing and maintaining multiple sources compared to the cost of contracting for larger production quantities. It is important to resist the temptation to accept at face value the comparison of actual SRM production costs to

costs that are estimated without actual experience of satisfying NASA's manned space flight requirements. It should also be noted that the projected economies are based on facilities that are not yet constructed or facilities that are yet to deliver a production motor.

There are other considerations in addition to cost. For example, NASA's management attention would have to be split between the two sources rather than being focused solely on the redesign. Further, the development of a second source for the RSRM would not improve motor performance and could also detract from flight safety and reliability. This potential could arise because of the slower generation of historical reliability data caused by a split production between two suppliers.

In summary, the development of an alternate source would have a negative impact on cost and would not offer any technical or reliability improvements to the system. Such action is not economically justified nor does it provide any other advantage to NASA or the nation.

In conclusion, Mr. Chairman, Morton Thiokol shares a common set of objectives with this Committee. Those objectives are: (1) return the Shuttle to safe flight and (2) provide the nation with a reliable, efficient and cost-effective solid rocket motor. This can best be done by developing and implementing a logical acquisition strategy to meet this nation's space needs. We believe NASA's acquisition strategy as provided to you in recent testimony is in this nation's best interest. It provides the most efficient, cost-effective and

safest approach. It does so without jeopardizing the current Shuttle program or introducing additional risk.

Mr. Chairman, I appreciate the opportunity to testify on this important subject and will be pleased to answer any questions the Committee may have.

ATTACHMENT TO STATEMENT OF
JOHN THIRKILL, MORTON THIOKOL, INC.

STATEMENT BEFORE THE

HOUSE GOVERNMENT OPERATIONS COMMITTEE

SUBCOMMITTEE ON LEGISLATION AND NATIONAL SECURITY

BY

EDWARD G. DORSEY, JR.

VICE PRESIDENT AND GENERAL MANAGER

MORTON THIOKOL, INC.

SPACE DIVISION

BRIGHAM CITY, UTAH

July 31, 1986

76-600 3824

Good afternoon, Mr. Chairman and members of the Committee. I am Edward G. Dorsey, Jr., Vice President and General Manager of the Space Division of Morton Thiokol, Inc., located in Brigham City, Utah. It is a pleasure to appear before this Committee to offer testimony regarding the solid rocket motor program at Morton Thiokol and to answer any questions you may have. I have with me today, Mr. Thomas J. O'Grady, Deputy Program Manager of the SRM Program, and Alan Housley, SRM Performance Management.

Mr. Chairman, I would first like to present to the Committee a statement regarding Morton Thiokol's role in the field of solid rocket motors for the space shuttle program. Following that, we would be pleased to respond to questions.

Morton Thiokol is the world's largest developer and producer of solid rocket motors. In fact, we were one of the first companies to be engaged in this activity in the United States. We manufacture solid rocket motors for strategic missiles, tactical missiles and space applications. Our facilities for this work are located in Alabama, Louisiana, Maryland, Texas and Utah.

When NASA began to seek a contractor to provide solid rocket motors for the space program, it conducted an extensive competition. Morton Thiokol submitted a proposal, as did other companies -- Aerojet, United Technologies, and Lockheed Propulsion Co. Following an extensive evaluation

of all the proposals, NASA awarded Morton Thiokol the contract to design and develop the space shuttle solid rocket motor. I'm proud to say that Morton Thiokol conducted this development program on schedule, within budget, and within specifications on all counts. Our cost performance over the eight years of development was 2.5% under budget, and we received "superior" ratings from NASA for our contract performance. This development program included hardware for the first six shuttle flights.

Morton Thiokol was also awarded two production contracts. The first contract was to provide solid rocket motors for shuttle flights 7 through 15. On this contract, our costs were 6.6% below budget. The second production contract was to provide rocket motors for flights 16 through 36. At the time the 27th set of rocket motors was delivered in December 1985, this contract was 2.9% below budget.

We also were able to reduce production costs from the first production unit to the 27th set by about 20%. We had proposed even further cost reductions for the third production buy. The third production contract is, of course, uncertain because of the status of the shuttle program.

During the development period, NASA decided that additional space shuttle payload capability was needed. It directed Morton Thiokol to make various changes to the solid rocket motor, which included development of a lighter steel case, as well as modifications to the rocket motor nozzle

and to the flight ballistics. These improvements made it possible to provide the shuttle with a payload increase of 3,000 pounds. Morton Thiokol met these requirements, too, within budget and on schedule.

Let me now turn to some of the technical and performance aspects of our solid rocket motors.

More than 500 metal and nonmetal parts are used to manufacture a solid rocket motor for use in the space shuttle. Each rocket motor is about 12 feet in diameter and 126 feet long. Each motor contains over 1.1 million pounds of propellant, and the overall unit weighs 1.256 million pounds. Each motor generates an average of 2.6 million pounds of thrust and burns for just over two minutes, creating an internal operating pressure of about 1,000 pounds per square inch.

It is important to recognize that this is by far the largest operational rocket motor ever produced. As an example, the weight of each segment is more than four times the weight of corresponding segment of the Titan III, the next largest rocket motor.

About 64% of the cost of a new motor represents purchases we make from other companies of supplies and parts. We buy parts and material from companies in 37 states. Some of our suppliers are unique in their field. Others are one of only a couple of available suppliers of a particular commodity.

There are some important items for which there is only one source. The steel case segment is the most important example. Other examples are items necessary for the propellant, the insulation, and the igniter. I might point out that any company producing the same design would have to buy parts and materials from single or dual sources which are already supplying them to Morton Thiokol. The only other option would be for such a company to incur the substantial expense of developing new sources. This route would be prohibitively expensive and would mean that reliance for important components would be put on unproven sources.

Another very significant cost item is the "hands-on labor" Morton Thiokol supplies. After we receive the parts and raw materials, manufacturing and assembly work is done in our plant to produce a finished rocket motor. The "hands-on labor" component is about 17% of the total cost of a motor. We have reduced our labor costs significantly over the course of the production contracts, as we have gained experience. This improved performance is one of the primary advantages of continuity with an experienced contractor. We expect further improvements in performance at a rate based on future production schedules.

The bottom line, Mr. Chairman, is that Morton Thiokol has produced these rocket motors in a very efficient manner. We will continue to do so when production resumes.

Recently, considerable attention has been given to the concept that a "second source" ought to be developed for the solid rocket motors. In evaluating that suggestion, certain facts must be kept in mind. Most important is the strength of Morton Thiokol's present capabilities. We already have developed facilities capable of producing 26 flight sets (i.e., 52 solid rocket motors) per year. This number exceeds NASA's previous estimate of the amount required to support its planned flight program of 24 flights per year. Given the tragic events of January 1986, and the subsequent reassessment of the entire shuttle program, it seems unlikely that future flights will occur at this previously estimated rate for some time in the future. If we are correct in that analysis, Morton Thiokol already has adequate production facilities, with excess capacity, to support the solid rocket motor program for the foreseeable future.

The concept of a "second source" always appears attractive on the surface. What is often not understood, however, is the burden of the additional facilities which have to be created to support a second source. Such facilities would be extensive. Even if NASA ends up paying just a portion of such costs, those expenses would be substantial. We do not see how any economies to the Government can be achieved by development of a second source at a time when existing facilities are more than adequate to support all of NASA's likely needs.

In addition, Mr. Chairman, we do not believe that this is the time to draw conclusions about the need for a second source. Given the redesign work which is necessary before shuttle flights resume, the precise future of the shuttle program and launch schedule is uncertain. It is certain that increased use will be made of expendable launch vehicles -- launch vehicles which put satellites in orbit without recovery of the launch vehicle itself. These developments increase the uncertainty as to the flight rate for the shuttle when it is back in operation. Only after these uncertainties are resolved can the need for a second rocket motor production source be meaningfully evaluated. Indeed, the development of expendable launch vehicles would go far to help resolve concerns expressed for the need for an alternate source of launches for both national security and commercial needs.

In the meantime, NASA, Morton Thiokol, and the other contractors and subcontractors associated with the space shuttle project all have much work to do. Our unified objective is to get the shuttle flying again in the shortest period of time consistent with safety, quality control, and reliability objectives. We are working closely not only with NASA but also with the independent oversight committee recommended by the Presidential Commission to achieve these goals. Under these circumstances, we believe any proposal for acquiring a second source should be tabled until the shuttle is flying again and a probable flight schedule is

established. It will then be possible for NASA to assess whether savings or other goals can be achieved by adding an additional source.

I would like to conclude by commenting on NASA's conclusions in December 1985 on the second source question. At that time, NASA announced that it had completed a lengthy review of proposals from four other rocket motor companies, each of whom wanted to establish a second source. NASA found no conclusive evidence that production cost savings would be obtained with a dual source procurement approach. Since it did not confirm any cost benefit to the government, NASA could not justify the duplication of facilities expense, tooling, and qualification costs required to set up a second supplier.

We believe that NASA's conclusions apply with even greater force today, considering the current status of the shuttle program.

Mr. Chairman, we thank you and the Committee for the opportunity to present Morton Thiokol's views. We will be happy to answer any questions that you or members of the Committee might have.

Mr. NELSON. Okay. Thank you, Mr. Thirkill. I want to compliment all the witnesses. You were to the point, you stayed within the time line, and I appreciate you honoring our request on time because of the large number of witnesses. And, obviously, you can see the interest by the membership here, so I want to give them plenty of time.

Now let me conduct a poll here, so that I can lay the predicate upon which then our members can proceed with the questioning. Let's just go down the list, and, by the way, if anybody wonders how the list came, it was in strict alphabetical order by the names of the witnesses. And there was a substitute from the original witness from Hercules, so that's why it doesn't look alphabetical there to you. So going alphabetically—yes, that's right. We submitted this to the Rules Committee and got the appropriate protocol. [Laughter.]

Mr. NELSON. Okay. Let's get a poll, with a raise of hands, of who thinks that the NASA-proposed advanced solid rocket motor is the best approach.

All right, Aerojet. Then, United Technologies. A half a vote from Hercules. And from Atlantic Research——

Mr. THIRKILL. A clarification. What do you mean by the best approach?

Mr. NELSON. Do you agree with an advanced SRM? You agree or not?

Mr. THIRKILL. Well, I agree with an advanced——

Mr. NELSON. As proposed by NASA.

Mr. THIRKILL. As proposed by NASA to improve payload capability; yes.

Mr. NELSON. Okay. All right, so we have everybody agreeing, with one qualification from Hercules. What's your qualification?

Mr. BIEHLER. The qualification of our interest, I see the—excuse me—the introduction of competition and our qualification, of course, as was stated earlier, was predicated on the assumption that there would be sufficient funding to fund that type of a program. So basically speaking, I'm more in agreement than I'm in disagreement.

Mr. NELSON. We're talking about NASA's proposed ASRM——

Mr. BIEHLER. Yes, sir.

Mr. NELSON [continuing]. Which is a competition.

Mr. BIEHLER. Yes, sir.

Mr. NELSON. So you agree with that? Winner take all?

Mr. BIEHLER. Winner take all.

Mr. NELSON. Okay. All right, next question. So we got basic agreement from all of you on that.

All right, now the question of GOCO, which is government-owned, contractor-operated facility, proposed by NASA. Who agrees with that? Okay. Aerojet. United Technologies.

All right. Do the rest of you disagree with that?

Mr. THIRKILL. Vehemently. [Laughter.]

Mr. NELSON. All right. How about Hercules?

Mr. SIDES. We disagree.

Mr. NELSON. Disagree. Hercules disagrees.

Mr. SIDES. Disagree.

Mr. NELSON. And Atlantic Research disagrees.

Mr. BROWN. May I offer a comment?

Mr. NELSON. Yes, sir.

Mr. BROWN. The facility located in Dade County, Florida, we had previously offered NASA the opportunity to buy that and turn it into a government facility.

Mr. NELSON. Okay. Let me get my tally sheet here. Okay.

Now the next question is, as to the advanced solid rocket motor—I want to get a clarification here—everybody here, do I understand, agrees that it should be a competition? Is that agreed?

All right, the choice now is a competition of winner take all, and the other choice is the second sourcing on the advanced solid rocket motor. We've heard testimony on both sides of that. Who would want winner take all on the advanced solid rocket motor? Anybody vote for that? All right. All right, ah——

Mr. BROWN. Just—excuse me. You know, at the conclusion of the subsequent phase. This is Phase C/D.

Mr. NELSON. Yes. I'm talking about the new motor for the 1990s. Okay, is there anybody that would vote for the winner take all in the competition? All right. All right.

Mr. CROSBY. I'd like to qualify my vote if I could.

Mr. NELSON. Go ahead.

Mr. CROSBY. I'd like to qualify it to the extent that, if the flight rate appears to justify competition at the time that the advanced solid motor is ready to put into production, then we would support an approach which would provide competition which might either be a leader/follower approach or competition, if there were a GOCO facility, a competition held every few years in order to operate that facility. So we're not opposed to competition where it makes some economic sense to do that from the national standpoint.

If the flight rate is what we might anticipate it will be in the near future, say 6-8 flights a year, we don't believe that that warrants competition.

Mr. NELSON. Okay. So what you're saying is that you may go with winner take all; otherwise, you'd go with second sourcing?

Mr. CROSBY. We would definitely go with winner take all. We would not be opposed—we would not stand in opposition to a——

Mr. NELSON. Okay.

Mr. CROSBY [continuing]. Multiple source arrangement.

Mr. NELSON. Okay. So Aerojet and United Technologies—and who was the other—Thiokol were in agreement with winner take all on the competition on an advanced solid rocket motor.

Now, on the question of second sourcing you said that under certain circumstances you would agree with that, United Technologies.

How about the rest of you?

Mr. BIEHLER. I think that Hercules would agree with the position that CSD just took; that being that if the delivery rates justify a second source or leader/follower that's the path we should follow, and if the rates are sufficiently low, then we believe the leader—the winner should take all.

Mr. NELSON. Okay.

Mr. SIDES. Atlantic Research's position is very close to that just stated by Hercules and United Technologies. We have consistently

supported a leader/follower approach as what we believe would be an acquisition strategy that would be in the Government's best interest.

We do recognize that under certain procurements of a limited number of flights that that would become impractical. But that's still our preferred acquisition strategy.

Mr. NELSON. Leader/follower, you're meaning second sourcing?

Mr. SIDES. No, not really. Again let me restate what we mean by leader/follower. [is,] In the case of the advanced motor your recommendation was that a team might develop that system and you['d have a built-in—and] would then compete among the teams. [or whatever, and] Then you'd have a built-in competition by the winning team. [and] That is, that the two one would members of the team—could compete with[in itself] themselves.

[The advantage of leader/follower even within the]—By the way, prior to the Challenger failure, Atlantic Research had recommended this strategy to NASA, even with the situation that existed at that point in time. And if I could take just a minute to clarify then [that] I think it would be better understood.

Our suggestion at that time raised [was that] a couple of major concerns about introducing competition into the SRM program. One concern was technology transfer, and that is, whoever wins the second source learning how to make that unit. Another concern was [and also] that it would require a drain on NASA management resources to have to manage two sources instead of one. And our suggestion was at that [point in] time to make the incumbent responsible for that acquisition and incentivize him to train the follower. Then NASA would guarantee each of them a minimum amount and [then] have a competition for the remainder, which could be a large percentage.

We still adhere to that same philosophy. Leader/follower is slightly different twist than what has been said, strictly second source or strictly winner take all. But we believe this acquisition when studied, might well fit the objectives of both NASA and the community.

Mr. NELSON. All right. Thank you for the clarification.

Okay, the next question on the poll. Now we're talking about the existing solid rocket motor as redesigned by NASA and Thiokol under the present redesign that they're testing. All right. The question is second sourcing. Who is in favor of second sourcing? As you know, NASA's position is that they should not second source.

All right, Hercules in favor.

Who is opposed to the second sourcing? All right, Aerojet and United Technologies.

Mr. SIDES. Again——

Mr. NELSON. All right.

Mr. SIDES. In my testimony, I submitted that we think that if ASRM funding cannot be secured that the leader/follower-type acquisition should be pursued in the case of the [redesigned] SRM. So.

Mr. NELSON. And, if ASRM is being developed, which position do you take on this?

Mr. SIDES. That ASRM should be, should be, ah——

Mr. NELSON. Yes, I'm saying that assuming SRM—the question is not now on ASRM, it's on the present redesign. Do you think it should be second sourced?

Mr. SIDES. Yes.

Mr. NELSON. All right. Mr. Thirkill?

Mr. THIRKILL. No, I do not. If you'll—my testimony will cover the subject on the RSRM. We do not believe that it is economical, economically justified to have a dual source on the RSRM.

Mr. NELSON. Okay, last question on the quiz. Then we'll get to—we're laying the predicate here for the committee. Now this question deals with the question of cost. Whether or not the net cost of the rocket motors would be higher if production were split between two contractors? In other words, if there's a second source. We're talking about in the range of 12 to 16 Shuttle missions per year, and the NASA position is, as testified to us by Admiral Truly, that the cost would be higher for a second sourcing.

Mr. BIEHLER. You're talking about the redesign.

Mr. NELSON. We're talking about the redesign of the present motor. We're not talking about the advanced solid rocket motor.

Okay. Now which of you agree with the NASA assessment? All right. Aerojet, United Technologies and Thiokol.

All right, which of you disagree with it? Hercules. Okay.

Now, with regard to Hercules, since you disagree with it, do you think that the second sourcing would save the Government money at a flight rate of 16 per year?

Mr. BIEHLER. Yes, we do.

Mr. NELSON. All right. Do you think that the second sourcing would save the Government money at a flight rate of 12 per year?

Mr. BIEHLER. Yes, we do.

Mr. NELSON. All right. Would you be willing to sign a fixed price contract in order to guarantee those savings to the Government?

Mr. BIEHLER. Yes, we would.

Mr. NELSON. Okay, why don't you explain that?

Mr. BIEHLER. I'd like to go back and draw to your attention that on the—and put on the record, on the recent competition where a second source was introduced on the Mark 70 what the savings were to the Government; on the HARM program, which was second sourced, the savings to the Government; and in no event have I ever seen a second source or a two source procurement result in more cost to the Government.

Mr. NELSON. Okay, let me turn to Mr.—the order will be Mr.——

Mr. KONNYU. Mr. Chairman?

Mr. NELSON [continuing]. Mr. Packard, then Mr. Torricelli.

Yes?

Mr. KONNYU. I wonder if you would yield on that specific point with respect to Hercules?

Mr. VOLKMER. I won't go the order, Bill.

Mr. NELSON. I tell you what. I think I would like to go on and get members——

Mr. KONNYU. All right——

Mr. NELSON. Members of the op——

Mr. KONNYU. I have to leave in 10 minutes that's why I want——

Mr. NELSON. All right. Well, we'll just yield to you before you leave. So you just butt in before you leave and we'll get to you.

Go ahead, Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

The flight rate is scheduled to not reach the 12 to 16 for two, maybe more, years according to NASA. During that period of time with six or seven as perhaps the maximum flight years, or flight rate during those early years, or these next early years, how would a second source pencil out under those conditions, Mr. Biehler?

Mr. BIEHLER. I think at the lower rates it does start to become questionable just where you trade off. I addressed the 12, and maybe to put that in perspective for the committee, we're recently ending up the Trident I program. It has a delivery rate of 8 motors per month. That's a sole source procurement.

The equivalency at a rate of 12 flights per month would equate to 32 Trident motors per month. So when we talk about low quantities on the Shuttle program, the SRM program, if you put in perspective, there's four segments for each motor, each one of those are a quarter of a million pounds, so there's 8 segments that are flying each time. So, you know, if you break it down to just how many motors you're delivering, you're delivering a lot of hardware and you're delivering a lot of product. You know, when we get down to 12 that's equivalent to 32 Trident motors per month.

Mr. PACKARD. Also, let me ask also the representatives from Hercules, in your judgment, would a delay, a further delay in our projected flight schedule being implemented a year from now about, would that occur if we went to second sourcing for the redesigned motor?

Mr. BIEHLER. I think that if we structured an acquisition plan that did, in fact, delay the Shuttle program it would be wrong. I think the Shuttle program is important to get flying. I don't know what plan that would be. I can see that it's a parallel path at least, so I don't—if it were to delay the Shuttle program, then it would be wrong for this country.

Mr. PACKARD. Are you then saying that it would not delay?

Mr. BIEHLER. I have not seen a reason why it should delay it. I do not know the overall acquisition, nor have we ever seen one presented by NASA for a second source option. So we're somewhat in the dark on exactly how they would approach the second sourcing.

Mr. PACKARD. So you're saying that you're not certain that the second sourcing of the redesign motor would, or would not delay. You simply do not know that.

Mr. BIEHLER. I simply do not know that, sir.

Mr. PACKARD. And yet, I believe you did say that if it does—if review does find that it would delay it, you would not favor that.

Mr. BIEHLER. That is right, sir.

Mr. PACKARD. Do you have other DOD or space contracts?

Mr. BIEHLER. We have——

Mr. PACKARD. Hercules?

Mr. BIEHLER. We have many DOD contracts.

Mr. PACKARD. Are most of those sole source or are there dual sourcing?

Mr. BIEHLER. Most of those in the tactical arena, most of those are dual sourcing—or a good many of them are dual sourcing.

Excuse me. In the strategic area, which are the FDN programs, the Peacekeeper programs and the small ICBM programs, there are usually three motors per stage and there is a contractor involved in each one of those. And they were secured under a competitive process.

Mr. PACKARD. Well, so—of course, so was the SRMs——

Mr. BIEHLER. Yes, sir. I wasn't——

Mr. PACKARD [continuing]. Secured under a competitive process.

Mr. BIEHLER. I wasn't skewing, I wasn't.

Mr. PACKARD. Generally speaking, do you find or would you feel that after research and development, we're into production, that sole sourcing or dual sourcing on the—as a general practice is the preferable way for the Government to go?

Mr. BIEHLER. I believe, and I think we've been consistent in this policy, that when the quantities are sufficient in the production mode that dual sourcing, two sources, are better for the procurement process; and I think that this is quite evident in the practices of the DOD procurements.

Mr. PACKARD. One last question, Mr. Chairman.

Mr. NELSON. Yes, sir.

Mr. PACKARD. What would be your reasons or your evaluation as to why Hercules with the companies presently represented here along with NASA is the only one that feels that there ought to be dual sourcing on the redesign motor?

Mr. BIEHLER. Oh, I would, not knowing what's driving or motivating the other companies at this table, I do know that Hercules has made the investment and does have the facilities, and do have them in a production mode to do something now. And I can answer you that way.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Sides, point of clarification on my last question up here. Did you agree or disagree with NASA's contention that a second source on the existing redesign of the SRB's would cost more? Did you agree or disagree?

Mr. SIDES. State it again, Mr. Chairman, I'm sorry.

Mr. NELSON. NASA has said that it would cost more to have a second source on the existing SRM redesign. Do you agree or disagree?

Mr. SIDES. Well, it's rate sensitive, of course. It depends on the acquisition.

Mr. NELSON. Twelve to sixteen.

Mr. SIDES. Twelve to sixteen. Well, we feel that a competition would be in order. And by the way, I might add, Mr. Chairman, there's only one way.

Mr. NELSON. Now the question is not is competition in order. The question is do you agree with NASA or do you disagree.

Mr. SIDES. I disagree.

Mr. NELSON. You disagree. Okay.

Mr. SIDES. And let me, if I may just add a comment in my disagreement because it's difficult to be put in little boxes and respond, you understand. But, and that is the only—I agree with Hercules to this extent. The only way NASA is going to get the answer to that question is to ask.

Mr. NELSON. All right. I wanted to get that clarified. All right.

Mr. Torricelli?

Mr. TORRICELLI. Thank you, Mr. Chairman. I wonder if I could ask generally, Mr. Chairman, recently NASA came before this committee and submitted its estimates on what the costs would be in second sourcing, exactly the question that the chairman has asked, and they submitted some numbers to us upon which we are asked to make a decision on whether to proceed with a second sourcing.

I wonder, with the exception of Mr. Thirkill's corporation, was anyone else asked by NASA—since the redesign of the solid rocket motors—their costs, what their cost of production would be?

So NASA came before this committee suggesting to us what the cost would be if—since you are the Nation's only manufacturers of solid rocket motors, would be and, as my colleague is pointing out for the record, you are all responding that none of you submitted that information to NASA.

Mr. BIEHLER. That is correct.

Mr. TORRICELLI. At a flight rate, Mr. Biehler, of 12 per year, so that in a second source your company would be producing 6 sets per year, would you give us an estimation on the—what you would estimate your cost to be?

Now I don't know the extent of your knowledge of the redesign motors, so you could either answer in terms of the redesign motors or, for purposes of comparison, the old motors since we know what the increase in cost seems to be.

Mr. BIEHLER. I will have to respond in relationship to the old motors because we are not that familiar with the redesign.

Mr. TORRICELLI. All right, then, Mr. Biehler, why don't you do that? Then, if you had been asked by NASA to be a second source on the old motors at a rate of 6 per year on a fixed price contract before the crash of the *Challenger,* what would your response have been?

Mr. BIEHLER. I think in our testimony earlier this afternoon we said that that cost would be $18 million for 12 flights per year, and that assumes that those 12 flights would be split on a basis of a 60–40-type split.

Mr. TORRICELLI. So you are assuming $18 million a set on 40 percent of the production rate?

Mr. BIEHLER. On 60 percent.

Mr. TORRICELLI. On you having 60.

Mr. BIEHLER. On us having 60; yes, sir.

Mr. TORRICELLI. Oh. I see.

Now, Mr. Thirkill, I've been worrying for an hour whether I could say Thirkill of Thiokol. [Laughter.]

Mr. TORRICELLI. Mr. Thirkill, of Thiokol, is it your judgment that Hercules in reaching their own conclusions about the ability to sign a fixed price at $18 million on 60 percent of the rate of the production, in your judgment, are they just simply wrong in doing their own calculations?

Mr. THIRKILL. Well, I'd have to look at their numbers and take a—you know, I'm not really qualified totally to answer that question, but their $18 million compares with the price of about $17 million that we were selling 51–L configured flight sets for.

Mr. TORRICELLI. If you were selling 100 percent of them?

Mr. THIRKILL. At that point in time we were approaching a 12 per year launch rate. We had not yet gotten to it, had not had a year's production——

Mr. TORRICELLI. Yes.

Mr. THIRKILL [continuing]. At 12 per year——

Mr. TORRICELLI. I understand that. But——

Mr. THIRKILL [continuing]. So we were pretty close to——

Mr. TORRICELLI. I guess the real——

Mr. THIRKILL [continuing]. That production rate.

Mr. TORRICELLI. I guess the real question I was looking at is, do you believe it is possible to produce that number of motors per year under that design for $18 million a set?

Mr. THIRKILL. I believe that it is very, very difficult to produce that many motors at that rate if you have to amortize, I believe they quoted a cost of $500 million in their testimony today, to qualify. That cost has to be amortized someplace.

Mr. TORRICELLI. Well, that gets to my next question. In discussions with NASA last week we were using figures of $160 to $180 million in qualification costs. Mr. Thirkill has cited a figure. Is there anyone here who takes issue with those numbers that this committee used in discussions with NASA?

Mr. BIEHLER. I think a point of clarification, Congressman, would be that the $500 million was quoted as a qualification cost for an advanced solid rocket motor, and not for the qualification of the existing design.

Another point of clarification, when I quoted the $18 million at the 12 rate, that included new hardware. I think what Mr. Thirkill might have been referring to, and I take a little bit of liberty in this because I don't know, could have been the refurbish pattern of what they were—the mode they were in at the 51-L.

Mr. TORRICELLI. I understand. So, then, otherwise we are in agreement on this redesign qualification costs of $160 to $180 million.

I wondered, Mr. Brown, and, Mr. Crosby, this position that your companies are now taking concerning competition of the current redesign of the solid rocket motors, are either of your companies in a position today, if there were a second sourcing announced for this design, to submit proposals for that competition? Do you have the facilities existing now and the ability in terms of that competition if NASA were to provide for it?

Mr. BROWN. We do not have in place the facilities to produce a replica copy of the solid rocket motor.

Mr. TORRICELLI. Okay. Mr. Crosby?

Mr. CROSBY. We do not. However, if the quantity of the redesigned boosters that was to be procured, if the flight rate were of sufficient quantity to, to make an economic investment, both on the part of the Government——

Mr. TORRICELLI. Well, I understand that. But, I mean——

Mr. CROSBY [continuing]. In this requalification program, we would provide those facilities. We do not today——

Mr. TORRICELLI. For the right quantity in the right time, my uncle would start producing them. I mean—I mean today, whether you could actually begin that production and submit a proposal.

Mr. Sides, do you have—is your company prepared to enter into that competition?

Mr. SIDES. Yes.

Mr. TORRICELLI. Now?

Mr. SIDES. Yes. It would be necessary for us to expand the existing facilities. I think I pointed that out earlier.

Mr. TORRICELLI. So, in fact, we have three companies in the country today that could enter into a second source if NASA were to proceed with it and we believed that the economics warranted it.

Mr. Sides, are you prepared to say on a fixed-cost basis on these rates of flights that we're talking about what in the old design it would cost? What your company could offer the Federal Government?

Mr. SIDES. Now I think—I want to make sure that I know what rates we're talking about.

Mr. TORRICELLI. We're talking about——

Mr. SIDES. Six?

Mr. TORRICELLI. We're talking about flight rates of, say, 50 percent of a contract. Well, let's—let's try to compare it with Mr. Biehler's. He was using 60 percent.

Using 60 percent of 16 or 60 percent of 12?

Mr. BIEHLER. That was 60 percent of 12.

Mr. SIDES. I think we—let me answer the question. I can answer the question. We have identified for 6 sets per year, or 20 years 2x6 sets per year, our number was including a buy of new hardware and a number of reuses, less than $17 million.

Mr. TORRICELLI. Less than 17 at that rate of flight?

Mr. SIDES. That's right.

Mr. TORRICELLI. So, Mr. Chairman, if you—could I have your indulgence? I just only have one or two questions more.

Mr. Sides, you cited that your company today, perhaps, was the largest producer of solid rocket fuel. If the Federal Government came to you today because for some reason Thiokol could not produce—industrial accident, a variety of other reasons—how long would it take you to get into production? How long would this country be without access to space?

Mr. SIDES. What you—you mean as far as the Shuttle itself is concerned?

Mr. TORRICELLI. I'm getting beyond the question of the competition. I'm moving beyond cost or competition. I'm now talking about national security.

Mr. SIDES. Yes.

Mr. TORRICELLI. If for some reason Mr. Thirkill, or Thiokol's company could not produce.

Mr. SIDES. Well, we could be——

Mr. TORRICELLI. Industrial accident, sabotage, whatever it might be. How long would it take you to produce?

Mr. SIDES. Really there's two parts to the answer to that question and let me tell you what they are. In the mixing propellant processing part of the question, which is the processing the ingredients, the mixing them together and taking them up to the point of being——

Mr. TORRICELLI. I don't want parts. I want the Federal Government calling you and saying there's been an accident, we have a

space program to be concerned about, we need to get in space, you're up.

Mr. SIDES. We could be in a very strong position I think in 12 to 18 months.

Mr. TORRICELLI. 12 to 18.

Mr. SIDES. Right. And the actual processing part, much more rapidly than that. That was the point I was trying to make, Congressman.

Mr. TORRICELLI. Okay. Mr. Thirkill, this committee has been told by NASA that in reaching the redesign of the solid rocket motors that the advice and good counsel of these other companies have been incorporated, that their advice has been sought, and that this design represents the best this Nation can produce based on the talents of all people.

In your judgment, are you prepared to stand behind NASA and say that that claim is accurate?

Mr. THIRKILL. Well, I guess I'm prejudiced. My answer to the question directly is yes, but I think I need to clarify it. We have outstanding contracts with Hercules and Atlantic Research to do work in support of us. We do not have a contractual commitment from Aerojet or the Chemical Systems Division. We have not, ourselves, undertaken a positive step to invite them to review the design. NASA has done that. They have been involved, I believe, in one presentation that was made concerning the RSRM before I came onboard at the Space Division, and I believe that NASA plans on having future involvement of the "experts" to review the status of the RSRM program.

Mr. TORRICELLI. But you are convinced that this design is the best the three leading companies in this country can produce?

Mr. THIRKILL. I think given years of time it could be improved. But I think that based on where we stand today in the program and short of demonstrating in the test program——

Mr. TORRICELLI. My question is whether it is an inclusive process. Not necessarily whether all parts of science have been exhausted in the time that was available, but whether you are prepared to say to this committee, as NASA has, that it is an inclusive process?

Mr. THIRKILL. I believe that it is, has been an inclusive process; yes.

Mr. TORRICELLI. Would anybody else like to comment on that? Not that it is necessary, but if you have a reaction to it.

Mr. CROSBY. Mr. Torricelli? Harry Crosby, United Technologies. I'd just like to comment that I think the question has to be in a context of the existing flight hardware, the necessity of getting the Shuttle flying again within a reasonable period of time; and within those constraints, we agree that the design that has evolved and that we have participated in review of is as good as could be done today.

Mr. TORRICELLI. That's only——

Mr. CROSBY. We do not agree that a better motor cannot be designed within 2½ to 3 years——

Mr. TORRICELLI. I understand that. That's—

Mr. CROSBY [continuing]. For an advanced booster system.

Mr. TORRICELLI. That's the confidence that I was looking for.

Finally——

Mr. BROWN. Congressman, may I make a comment?

Mr. TORRICELLI. Certainly.

Mr. BROWN. We submitted a proposal to NASA to actually produce what we consider to be an improved motor; that is, a motor that would utilize the current hardware that's available in the Shuttle, that is, the motor segments, the case hardware and so on, but that we would assemble it in one piece, completely insulate the interior surface of the motor and cast a one-piece propellant grain, which we think is a superior design from the standpoint of reliability and reduction of failure modes than the current redesign motor.

We've proposed to NASA that we would use a facility that exists, is in place in Dade County, Florida, and that we could produce hardware for testing in 18 months. Now NASA chose not to act on our proposal, but we did give them that proposal a year ago.

Mr. TORRICELLI. Finally, the economic question of whether or not second sourcing saves NASA money depends probably on the largest variable, which is the question of whether or not there will be an advanced solid rocket motor and when it will come in production. To the extent that any of you are prepared, or willing, or want to do so, I'd appreciate your comments.

Given the 1995 time frame and the competition from a Space Station, the then use of a heavy launch vehicle, other NASA priorities, are each of you convinced that at that time or near to it, recognizing that the end of the Shuttle program probably comes some 15 years later, that NASA will, in fact, have an advanced solid rocket motor?

Mr. CROSBY. Mr. Congressman, I would like to respond by saying that it makes as much sense to us to believe that they will be able to afford an advanced solid rocket motor as they will be able to afford to qualify the current design which is deficient in performance. In other words, why spend $150 or the $160 million—I'm not sure exactly which set of numbers apply—that you mentioned to qualify this current design going within a time period of 2½ to 3 years, as we've mentioned, you can use that same money to qualify a superior design. And then you have a motor that can support a very viable flight program for the next 15 years and perhaps beyond that, because you will have a greater reliability, undoubtedly a lower cost propulsion system, and you'll be able to sustain much higher flight rates than you will ever be able to support with the current redesign booster.

Mr. TORRICELLI. Yes. I didn't want to get in a debate over it; I wanted the question answered. But I'll just suggest to you the question is that we're not talking about a couple of years—Mr. Chairman, correct me if I'm wrong—but my belief is we're talking about the actual large-scale use of an advanced solid rocket motor not before '94 or '95. Am I not correct in that?

Mr. NELSON. NASA's estimate is '95.

Mr. TORRICELLI. Is '95. So my question is whether we spend those sums of money to develop an advanced solid rocket motor after supposedly, hopefully, at that point we will have had 7 or 8 years of solid experience with this redesign produced by Thiokol, then for the last 15 years of the Shuttle project, before NASA tells us the Shuttle is out of date, we want to switch designs, go to something

new after this has proven itself at a much greater cost given all the competition in NASA. That was the basis of my question. But I was asking you to look at crystal balls more than relay facts, so I understand if you don't want to address the point. But I wanted to make it anyway.

Mr. CROSBY. Crystal-balling is a difficult challenge.

Mr. TORRICELLI. Though not unique in this room.

Mr. CROSBY. Though not unique.

Mr. SIDES. Mr. Chairman, I might add I think that, you know, the evolution of many programs—in the DOD they call it product improvement, PIP programs—do occur. I think to view the redesign motor and the advanced motor as totally separate entities, totally independent one of the other, is really a mistake. I think that those who are interested in competing for the Shuttle solid rocket motor business could very well elect to view both as being attractive targets. So again, I think that, you know, that one thing about advanced programs sometimes, and that is as they continue to slip the current program continues to go on. So it tends to, from an acquisition strategy point of view, create an enigma for the procurer.

Mr. TORRICELLI. Thank you. And thank you, Mr. Chairman.

Mr. NELSON. Okay. In checking back on a chart provided by NASA, they show a qualification of an advanced solid rocket motor by the end of '93, the first production delivery to come out in late '93, and 8 to be delivered in '94.

Okay, the committee will recess for this vote and we will come right back, and we'll have up Mr. Buechner and Mr. Hayes.

[Recess.]

Mr. NELSON. Okay. It's Mr. Buechner, and then Mr. Hayes.

Mr. BUECHNER. Thank you very much, gentlemen, for coming here today.

I've got a few questions for Mr. Sides. Mr. Sides, you mentioned the leader/follower program. What leader/follower programs are currently in existence in the rocket motor industry, and would you evaluate their successfulness?

Mr. SIDES. Ah, a couple of examples that I can give you. One that my company is involved in is a program out of the Joint Cruise Missile Project Office, which is called Tomahawk, and the solid rocket booster on the Tomahawk program. And there are actually two leader/follower programs involved: one for a booster motor that was developed some years ago by my company, which we're the leader, and another of a company that is represented at this table here today and is the follower; and another program in which, an advanced version, my competitor is a leader and we are the follower.

I believe that, and as I said earlier, with sufficient production rate, it provides a number of advantages. I believe that the joint cruise missile people feel it has been successful. The best way for you to get an answer for that, of course, would be to ask them, rather than me.

Mr. BUECHNER. Tell me, with that pro—with the Tomahawk program——

Mr. SIDES. Yes, sir.

Mr. BUECHNER [continuing]. For instance, let's just break one out. Tell me how the scheduling works and how the technical progress occurs.

Mr. SIDES. Well, typically, one thing you have to do right up front is one of the two competitors has to be the design agent, so if there are any technical changes that are required as things move along, somebody has the responsibility for—typically, the leader would have that responsibility. So, technically, it's a technical data package that's a mature technical data package but someone is in charge or being responsible for those technical issues were they to need changing or need modifying or updating, and so on.

But beyond that it's basically an RFP, or request for proposal, that comes out in which you bid on various quantities. Typically, a minimum sustaining rate would be identified, but—20 percent, 40 percent, 60 percent, 80 percent, and in some cases, particularly as the program matures out, perhaps even 100 percent. And then the selection is made on whatever basis the RFP is—defines, but if on a pure cost basis, it can be done on the basis of lowest cost to the Government, where the two numbers are added, the bids of the—at 20 percent, 40 percent, 60 percent, 80 percent and so on, are added and then the award is made to the lowest—to the number that is the lowest to the Government.

Of course, there are advantages to this, that accrue to this other than purely economical and by virtue of the fact that a warm base is maintained in two facilities and, ah—so that—and I believe that the Tomahawk people would tell you, and again it's—I'm probably not the best one to make that, to make that, reach that conclusion, but I believe that procuring people would tell you that that is, and has been a success, a successful acquisition strategy.

In fact, Tomahawk has used a similar situation, and I'm not qualified to comment in detail on this, but they've used that at the prime and at the airframe level as well involving, I believe, General Dynamics and McDonnell Douglas. And McDonnell Douglas, who's the follower on the program, I believe in the most recent procurement won the majority of the competition, which—and that's been a fairly well-publicized competition so it would be easy to get that data.

Mr. BUECHNER. Now just contrasting it for a moment, I believe your company, ARC, has the production contract for the rocket motor for MLRS——

Mr. SIDES. Yes.

Mr. BUECHNER [continuing]. For the Army; right?

Mr. SIDES. Right.

Mr. BUECHNER. Now I think that's one of the largest production programs in existence today.

Mr. SIDES. I don't know. It's a large——

Mr. BUECHNER. It's up at——

Mr. SIDES. It's a large production contract.

Mr. BUECHNER. If it's not at the top, it's certainly in the top few.

Mr. SIDES. That's right.

Mr. BUECHNER. Would you recommend that the Army go to a second source for that?

Mr. SIDES. Well, I think that the second source on MLRS is being considered now. The MLRS was procured initially under a multi-

year procurement, and I think that acquisition strategy can't be generalized. I think that you have to apply the acquisition strategy based on the objectives and the priorities of the acquisition. The MLRS program was competed in its early development phase, as was SRM. The decisions were made on the basis of competitive proposals including firm prices for multi-year procurement. And for that particular acquisition, the Army made a decision that that was the best acquisition strategy.

So my answer to the question would be that the acquisition that ought to be employed is the one that's in the best interest of the Government from a cost and availability point of view.

Mr. BUECHNER. Mr. Biehler, what investment do you calculate would be needed to qualify your company as a second source?

Mr. BIEHLER. Ah, excuse me. We have recently made an investment in a modern automated rocket motor factory in Salt Lake City, Utah, and that investment is, roughly, about $140 million. Now that facility also has some other programs going into it but is designed for the capacity looking to the large booster rocket motor.

Mr. BUECHNER. And have you done an estimate of how many Shuttle flights it would take to recoup that investment?

Mr. BIEHLER. We, early on, when we were looking at the structuring, the added features for the large booster, felt that in order for it to trade it would have to be in the neighborhood of about 6—6 flights per year.

Mr. BUECHNER. Now, and I'm not playing games with you, I think a year ago before Government Operations your company testified with a $100 million investment it would take 10 flights a year to recoup it. Now it's—with 140 you're telling me 6 flights would recoup it?

Mr. BIEHLER. I don't know the basis of the product mix they had in that facility at that point in time. Currently, the Trident II is in there, and also the Delta II is being developed in that facility. So the base may have changed enough that the numbers may be explained that way.

[Pause.]

Mr. BIEHLER. That's——

Mr. BUECHNER. Oh. Okay.

Mr. BIEHLER. I've finished my answer. I don't know.

Mr. BUECHNER. I thought you were talking to your counsel, I didn't know.

Mr. BIEHLER. No. No.

Mr. BUECHNER. Well, that's the wrong hearings. I'm sorry. [Laughter.]

Mr. BIEHLER. Thank goodness.

Mr. BUECHNER. Mr. Chairman, if you wouldn't mind, Mr. Packard had one extra question to ask and I'd like to yield to him.

Mr. HAYES [presiding]. Well, it would have to be better than the last questions. I've been avoiding him. [Laughter.]

Mr. PACKARD. Thank you, Mr. Buechner, and, Mr. Chairman.

Hercules has projected theirs on the basis of them having the 60 percent. If you had to produce 40 percent of the second source, what would your per copy cost be?

Mr. BIEHLER. I don't——

[Pause.]

Mr. BIEHLER. I'm a little bit hesitant not having seen the data, but I'll give you a number that my colleague just gave me. He said they would be about $2 million, Delta.

Mr. PACKARD. About an additional $2 million per copy.

And I believe I understood your testimony that it did not include, and, in fact, none of them would have included the qualifying costs of about, well, NASA's numbers were—the other day was $160 to $180 million, and that's not included in your projected costs?

Mr. BIEHLER. That's—that's correct, sir.

Mr. PACKARD. And if we—the optimum flight rate gave us, from now until the phase-in time of the AS, or the advanced solid rocket motors was about, would be—at their optimum would be about 80 flights. Realistically, it could be below 60 flights. If it were 80 flights, that's an additional then to amortize the cost of qualifying as a second source, 2 million, up to 3 million if it were around 60 flights. That would be an additional $2 to $3 million.

So, you see, if we're looking at the cost, we're looking at 2 million if, in fact—for the, whoever the 40 percent would be, whether it would be Thiokol or whether it would be some other second source contractor, and average those out, you can see that we could be as much as $5 million per copy over the $18 million figure per copy that you have given us in your testimony.

And then I guess the next question would be to Thiokol. You have produced, you indicated in the question and answer period, Mr. Thirkill, that you had produced your last one at Challenger time at $17 million.

Mr. THIRKILL. Those were the costs at the time of the Challenger; that's correct.

Mr. PACKARD. In your judgment, could the company still produce them at $17 million per copy once we start our flight rates back up again?

Mr. THIRKILL. When we get back up to a flight rate that was the equivalent to what it was at the time of the incident, the costs will be higher on the RSRM than they are, than they were on the solid rocket motor because of additional inspection requirements, nondestructive testing that has been levied by the customer, and support costs are going to be higher because of the increased staffing in the reliability, safety and quality areas.

Mr. PACKARD. How much higher would you project they would go if you were cut back to 40 percent of the projected flight rate?

Mr. THIRKILL. We have not looked at that, and so I'm not capable of providing the answer now. I'll be happy to provide that as a separate input, though.

Mr. PACKARD. One last question, if I may, to Hercules. In projecting your costs, you calculated—I wanted to make, this question is directed toward making certain that we're comparing apples with apples. You've project—in your projected costs you calculated the fabrication of the hardware, the pouring of the fuel and the testing in the field, the shipping to the site, launch site, and then the picking up of the hardware and shipping it back to the manufacturing site and then refurbishing that hardware, and then starting that cycle over again. That includes all of the process from one cycle to the next?

Mr. BIEHLER. No, sir. The costs for the recovery and the costs for the refurbishment we didn't feel would be justified by having two sources out there doing it at the same time, so it only includes the manufacturing of a solid rocket motor plus the shipping.

Mr. PACKARD. I see. Any projected costs of that phase or that portion that would be, that has been deleted? Do you have any calculations that could enlighten us on that, Mr. Thirkill?

Mr. THIRKILL. Ah, excuse me just a minute.

[Pause.]

Mr. THIRKILL. My cohort tells me that our costs at the present time for refurbishment, recovery and refurbishment, the activities that we perform to get the hardware back to flight status, adds about 15 percent to the cost of the motor.

Mr. PACKARD. About 15 percent.

Mr. THIRKILL. Right.

Mr. PACKARD. I appreciate very much the yielding. Thank you.

Mr. BUECHNER. If I could reclaim my time for just a second, Mr. Chairman.

To Mr. Biehler, if you could get a copy of Mr. Metinette's testimony—I don't know if that's how it's pronounced, but Mr. Metinette, and it's July 31st, 1986. I'd like you to give me a response to the difference between the answers in that testimony and today, if you could do that.

And, also, Mr. Chairman, I'd ask that all witnesses respond to any written questions that would be submitted later.

Mr. HAYES. Yes. Certainly.

[Material referred to follows:]

HERCULES

Hercules Incorporated
1800 K Street NW
Washington, DC 20006
202—223-8590

June 18, 1987

Mr. Bill Nelson, Chairman
Subcommittee on Space Science and Applications
U. S. House of Representatives
Committee on Science, Space and Technology
Suite 2321, Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Nelson:

Hercules was pleased to have the opportunity to testify before your subcommittee on Space Science and Applications on May 6, 1987, and to present our views on alternate procurement strategies for Space Shuttle Solid Rocket Motors. As we discussed during the hearing, we share your concerns over NASA procurement policies and hope that our participation will encourage your subcommittee to pursue a direction that will provide a cost effective operational Space Shuttle program.

During the hearing Mr. Buechner requested that I clarify a point in my testimony that differs from the position taken by Mr. Mettenet when he appeared before the Government Operations Committee regarding flight quantities required to achieve a reasonable return on investment. Attached is the response to Mr. Buechner's request as stated in your letter of June 3, 1987.

Again, thank you for the opportunity to participate in this most important hearing.

Very truly yours,

Bruce A. Biehler
Hercules Aerospace
Group Vice President
Propulsion Programs and Marketing

BAB:eb
Attachments

GOVERNMENT OPERATIONS COMMITTEE COMMENTS
vs
NELSON SUBCOMMITTEE COMMENTS

ISSUE: INVESTMENT RECOVERY

MR. BUECHNER: Mr. Biehler, what investment do you calculate would be needed to qualify your company as a second source?

MR. BIEHLER: Ah, excuse me. We have recently made an investment in a modern automated rocket motor factory in Salt Lake City, Utah, and that investment is, roughly, about $140 million. Now, that facility also has some other programs going into it, but is designed for the capacity looking to the large booster rocket motor.

CLARIFICATION:

Mr. Biehler was referring to our $140 million facility investment, not the funding required for qualification. Mr. Buechner assumed that this was the required qualification dollar level. During Mr. Mettenet's testimony before the Government Operations Committee, he testified that a $100 million investment would require a 10 flight/year rate. The actual qualification cost as stated by NASA maybe $160 million. Assuming a 50/50 split, of the qualification cost between NASA and Hercules, Hercules' share would be $80 million. Our analysis predicts a payback for an $80 million investment in the third year of production at a rate of 7 flights/year. This includes all associated costs and a baseline of $25 million for Thiokol motor sets.

ISSUE: PRINTED RESPONSE TO GOV OPS COMMITTEE

The data entitled "Hercules Response to Prepared Questions" indicate that an 8 to 23 year time frame is required to recover a qualification investment of $100 million depending on flight rate and nozzle procurement philosophy.

CLARIFICATION:

The data presented in the July 31, 1986, response does not include any sharing of the cost savings. Using the NASA published $25 million/year cost of the RSRM, a cost savings of $4.0 million to $8.0 million per set can be achieved depending on flight rates [i.e., if Hercules builds 7 flights per year a total savings of $333 million will be saved over a 1991 through 1998 time frame]. When the savings are shared, NASA recovers their qual investment in 1993.

Mr. HAYES. I think we're about to vote again. The gentleman from California, Mr. Packard, had the previous question. He just forgot to tell you it had a lot of parts. [Laughter.]

Being the only Democrat left, I have a new respect for the term "détente" I did not have earlier in the afternoon.

If that, and I believe most of our cast has left us. If there are not particular questions that somebody feels an urgency to address, we may take the opportunity to go vote and conclude the hearing at the same time.

Of course, if the gentleman from Missouri could write clearer, I could read this note. [Laughter.]

All right. I'm going to ask for unanimous consent for the members of the subcommittee to submit opening remarks immediately following the chairman's and assume there are no objections to that. Then, so ordered.

And if there are no other questions—let's recess for this vote. We'll come back immediately following the vote. If we cannot round up another Democrat, then I'll ask a few questions for the record, make it complete at that time.

And so we'll adjourn for approximately 10 or 15 minutes to record the vote. Thank you.

[Recess.]

Mr. NELSON. We'll proceed.

Mr. Hayes?

Mr. HAYES. Yes. Thank you. All I did was go vote and they fired me. [Laughter.]

I had wanted earlier to ask, really, a question on volume. I come from in real life a construction firm, and what it appears to me that we have is a question of whether second sourcing is justified by the volume in this instance instead of, what I'm familiar with, in volume of pure product, volume of flights. And I would like to ask Mr. Thirkill, and then those others of you who would like to respond. From your own in-company analysis, there must be an impression you have of the number of flights at which second sourcing becomes economically feasible; and, if so, I'd be most curious to know how that's arrived at and what your opinion is of the number of flights which is the cut-off point.

Mr. THIRKILL. Well, we have not done an analysis of that type because in the original SRM competition the intent of that competition was to create a source for the SRM and make the selection on a competitive basis. That was done. It was considered, and my memory may be failing me here, but I believe that in the original RFP it indicated that following the DDT&E program, the design, development and test activity, that NASA would procure the initial 54 flight sets through what was then defined as Increment II from the winner, and then the competition would occur on Increment III, which at that time was for an additional 770 rocket motors and that is 335 flights.

So we have never really seriously addressed the issue at where we feel a break point would be. We have our facilities in place. I believe, well, we would like to see it stay sole source. We can support 24 flights per year. We have that facility in existence.

Now, if you ask me are you willing to compete on a split buy, my answer to that question is yes, because I have the facility and I need to keep that facility gainfully occupied.

Mr. HAYES. What I'm really asking is, if 24 became 12, would you agree with the general proposition that second sourcing is not as economically feasible if you drop the number from 24 to 12, even though I may not be able to tell you whether it's at 16 or 18, precisely where there's a crossover in that feasibility?

Mr. THIRKILL. Well, I think you have to not only look at the flight rate per year, but you have to look at the total quantity buy. At the flight rate that is currently defined by NASA for the RSRM in their current procurement strategy, it does not make economic sense to us to compete the RSRM.

Mr. HAYES. Anyone else who would care to comment on the same question on the annual flight numbers and the economics of that in second sourcing?

Mr. BIEHLER. I'd like to make one comment, if I could.

Mr. HAYES. Yes, sir.

Mr. BIEHLER. And I certainly agree with, ah, some of, of Mr. Thirkill's comments that the volume sensitivity most often is a driver for when second source is really feasible. The analyses that are necessary to make a decision of a break point is probably company peculiar and it depends a lot on their long-term programs and the other programs they have in plant. But, as far as Hercules, we have facilitized and have the capability to participate where our share of whatever that flight schedule may be at 4 flights, 4 launches per year.

Mr. HAYES. I see what you're saying and understand.

I might ask you, too, and I'll ask Hercules and then anyone else who would care to comment, would—assume that we did this in just the opposite from the impression we're given of the government-owned. If, instead, we were talking about moving the entire project including administration—in other words, all of NASA—into private industry instead of talking about the government-owned facilities, what then from a corporate view of pure finance would you be doing, looking at your own subcontractors, when you roll that in?

In other words, would you second source your own subs in that instance of if you were running the whole show?

Mr. BIEHLER. Again, I, I think that there's not probably a general answer, and I'm not trying to beg the question. We recently have done that on a major procurement where we thought that the risk, the schedule, the cost competition, was in the best interest of the program to start that out from the very development stage as dual sourcing.

Mr. HAYES. Yes, sir. Mr. Thirkill——

Mr. THIRKILL. I'd like to comment on that. Wherever possible it is a reasonable idea from a—to have dual sourcing. But I've got to tell you something. That many of our suppliers, and I think this is something that a lot of people do not understand. Many of our suppliers are involved in the Shuttle program or in some of our missile programs because of the dedication that they have to their country, not because of the volume of business. It's not that attractive to you—to them? The volumes of business in many instances are very,

very low. There is one supplier of the metal forgings that are used for the SRM case. That company, when they got involved in the Shuttle program, didn't do that out of a sense of competition, because they were providing pipe for the Alaskan pipeline at that time and the dollars to be gained in their industry were in providing forgings in a mass production rate. But they had been known and are known as one of the foremost forging houses in the country and the management of that company at that time was very dedicated and very patriotic, and they did it principally from that standpoint, because it was not a financial situation for them.

So you have to be very careful, in my mind, when you address dual sourcing from a volume standpoint because, typically, in the solid rocket motor business there is not sufficient volume to justify dual sourcing.

Mr. HAYES. Thank you very much. I appreciate that. And we've kept you so long, I'll be kind enough to conclude.

Mr. NELSON. Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman.

I'd like to ask you gentlemen what's the largest size rocket motor you, this type that you have fired? I believe that Aerojet General fired a 260-inch; is that correct?

Mr. BROWN. That's right.

Mr. LEWIS. How about, Mr. Crosby, you? You had——

Mr. CROSBY. Yes. United Technologies is the—yes, we manufacture the Titan solid rocket booster which is 10 feet in diameter and 80 feet long. It's roughly some 50 percent or 55 percent the size of the Space Shuttle solid rocket motor. I believe it's the second largest solid rocket motor produced in the world.

Mr. BIEHLER. On the——

Mr. LEWIS. Mr. Biehler?

Mr. BIEHLER. If I could qualify it a little bit here. On the Trident II program where we are in a joint venture with Thiokol, we provide the casing, they perform the loading, and then we, in turn, static test it. So, to answer your question, what is the largest motor you've tested, it would be a 90,000-pound, high-energy, class 1.1 vehicle rocket motor.

From the standpoint of the largest motor we, Hercules, have cast, was a 40,000-pound motor—right small by these standards—in the Trident I first stage program.

Mr. LEWIS. Mr. Sides?

Mr. SIDES. We, like Hercules, are in the thousands of pounds range. We've been known as an intermediate size rocket motor house. Typically, 2,000-3,000 pounds would be the largest motor. As I commented earlier, our major claim to fame as far as our participation here is volume production of propellant, which is hundreds of thousands of pounds. We're currently producing about 400,000-450,000 pounds a week.

Mr. LEWIS. Um hum. Well, you can answer if you want to, Mr. Thirkill——

Mr. THIRKILL. Well, we have built and cast a motor, several motors, over 156 inches in diameter, but the largest motor from the propellant weight standpoint that we have manufactured is the SRM for the Shuttle.

Mr. LEWIS. Okay. I don't know for sure, but I know Aerojet General and I believe UTC. I don't—Mr. Biehler, was Hercules involved in initial RFPs for the Shuttle SRB?

Mr. BIEHLER. No, sir. We did not respond to that request for proposal.

Mr. LEWIS. How about you, sir? Okay.

Did Aerojet General, on their original design of the—Mr. Brown, in your RFP, was it a monolithic design or was it a jointed design?

Mr. BROWN. It was actually—a true monolithic design is the case also was a one-piece or monolithic case and it's a true monolithic motor, and it was proposed to be done in the facility in Florida.

Mr. LEWIS. How about you, Mr. Crosby—UTC?

Mr. CROSBY. You know our original proposal for the Shuttle solid rocket was 1972. We proposed a segmented motor which was very similar to the Titan solid rockets, equal length-to-diameter segments at that time. More recently, in the recent Block II Shuttle booster studies we worked very hard to analyze and study a monolithic approach based on the use of the existing Shuttle case segments joined and then with the field joints eliminated and factory insulation placed over the joints, as Mr. Brown described earlier in his initial testimony.

We think that the NASA recommendation to study in greater detail both a segmented motor and a monolithic motor is an ideal way to proceed toward an advanced booster. We recognize there are many concerns over the handling issues and the logistical issues concerning the monolithic motor approach and we feel that it is in the best interest of the space program and the Nation, as a matter of fact, to get those issues thoroughly studied and analyzed and get some answers in hand, and then proceed with an improved booster, either monolithic or segmented.

Mr. LEWIS. I see. Mr. Brown, how much do you feel that your company would have to provide in the capital outlay to get the Dade County facility on line in order to second source on this proposal?

Mr. BROWN. The estimates that we provided earlier were essentially a total of about $160 million——

Mr. LEWIS. Um hum.

Mr. BROWN [continuing]. Which involved the bringing the facility back to operating condition since it is sitting there, and also producing 3 articles for test.

Mr. LEWIS. Okay. Now how would you transport that monolithic motor from the Dade County facility to the Cape?

Mr. BROWN. We'd use barge transportation. There is a canal that's 100 feet wide, 12 feet deep, that comes right into our facility that has access to Barnes Sound and the Intracoastal Waterway, and so we would move by barge from the facility, down the canal to Barnes Sound, and then out to the ocean just below Miami.

Mr. LEWIS. I see. How would you get—you, Mr. Biehler, have a monolithic design as well. Is that what you're discussing?

Mr. BIEHLER. No, I am not discussing the monolithic design. It would be the segmented.

Mr. LEWIS. You're going to do the segmented motor?

Mr. BIEHLER. Yes, sir.

Mr. LEWIS. Okay. Then I won't ask you another question.

I don't have any other questions at this time, Mr. Chairman. I do have some that I would like to ask in writing.

Mr. HAYES [presiding]. And I'd—there's no one to object but me, and I certainly don't object. So, that covers that.

I'm going to try to cover some of those things that Chairman Nelson was interested in. I think he'll return in a moment, so if I appear to be stalling, that's very perceptive of you.

I would like to take this opportunity while stalling to comment on Mr. Thirkill's previous remark. I wish that in the current advertising concerning the Space Station some of the elements of what you previously said about so many companies in this country that are doing work related to the exploration in space are doing so at no great economic benefit to their company compared to other markets available to them through conversion. I think that the American people are strong supporters of this program, far stronger than my colleagues in the Congress—not on this committee—might perceive.

The fact that the Kennedy Space Center is the largest—third largest tourist facility in the State of Florida attest to both the emotional attachment from the 1960s and the ongoing and current understanding of the importance of so many of our research projects. I think that perhaps some of that advertising effort could be directed toward making that which all of you know in dealing with your subcontractors better known.

And the conclusion I would like to make after your remark is that I suspect that what you're telling me reinforces the position that the second sourcing is not going to have as dramatic an impact as it might in other government programs. Because what I concluded from what you're saying is that, unlike the construction industry I'm familiar with, there are instances where there are very few subs dealing in very, very limited production of products and therefore, with all of you having some equal overhead and general management costs dealing with a fewer number of subcontractors, there's not going to be an extraordinary difference coming from competition unless the flight numbers per year become huge and someone can find an edge in cutting of costs internally within management.

I suspect somebody disagrees with that, and I'd like to hear that, too. I would—objectivity is sometimes forced upon me by listening to people that know more than I do. I'd be interested in anyone that wanted to comment on that. As to whether the limited number of subcontractors does not, in fact, equate this industry a little differently than it might contractors bidding on a facility of 2 million square feet of office space to be constructed.

Mr. BIEHLER. I think that I'd like to comment, if I could, sir.

Mr. HAYES. Yes, sir.

Mr. BIEHLER. Not having a lot of familiarity with the NASA subtier contractors, but generally speaking, I would assume that, in part, at least a large portion of them are also the same subcontractors that service the other parts of the propulsion industry; and a lot of the hardware, what we are talking about second sourcing at a lower level, is reusable, so therefore the market really is a much smaller market for them to participate in.

Mr. HAYES. Oh, Mr. Walker is here to harass you. But what I'll do then instead is recognize the gentleman from Pennsylvania for any questions which he has.

Mr. WALKER. I have no questions, Mr. Chairman.

Mr. HAYES. Oh, you can't do that, I'm stalling. [Laughter.]

Can you believe that I got him the only time in his life he didn't have a question? [Laughter.]

In that case, then, let me take my best shot. It's terrible to try to read someone else's notes and their mind. I'll do my best and let the chairman fill back in.

Mr. THIRKILL. I can take a moment of your time, if you have some time.

Mr. HAYES. I would be delighted.

Mr. THIRKILL. There has been some discussion that we've heard about the threat of competition and its impact on our unit cost, and the steep decline in the learning curve that has been experienced on the Shuttle program. I would like to comment on that because the steep decline that has been experienced in the learning curve on the Shuttle program, if you're a student of learning curves theory, is exactly what a learning curve does. In the early phases of motor production when you start at unit one, which is usually the basis for the establishment of a learning curve, if you're on a 50 percent learning curve, the next point costs 50 percent of the first point, the next two items cost 50 percent or—I'm sorry. Each subsequent item costs you 50 percent of what the preceding item cost. And so it's like stepping to infinity—you never quite get to the point where cost is zero; and, in fact, as you go down the learning curve it becomes extremely flat and it takes extreme quantities to show any significant improvement.

Now there are things that you can do to change the learning curve. After you have been involved in the process, you can identify those pinch points that exist in the process. You can modify your process and that will show up on a learning curve as a step decrease in unit cost, because you have taken a lump of time out of the process by improving it.

And I hope that that might clarify where we're coming from or the relationship of learning curves to competition.

Mr. HAYES. You must be partly clairvoyant: that was the chairman's second question. And I might add that he had made the observation, too, and asked if you, in particular, and then anyone else who would care to, comment on the claim made that just the mere threat of competition a year or so ago had caused a 10 percent reduction in unit cost at Morton Thiokol.

Mr. THIRKILL. Well, threat of competition, I don't know what that means for sure. You know, we live in an environment of continuing competition and we are constantly, and I think somebody at the table here today said it earlier, that we're constantly striving to improve our method of doing business and our processes, and what have you, to improve our ability to compete. And so competition is a continuous threat. It's not something that happens today and goes away. It's going to be here tomorrow. It's going to be here next year.

So I would take issue that we showed a 10 percent reduction in our unit cost as a result of a threat of competition.

Mr. HAYES. Would anyone care to comment either generally on the learning curve or the unit cost question?

Mr. BIEHLER. I think what John went through, the learning curve, that it's absolutely correct. As far as the threat of competition, I think NASA is the only one who could address that because as far as I know they're the only one that has access to the numbers. Certainly we don't.

Mr. HAYES. All right. And I'll withhold the rest of the chairman's questions and recognize the gentleman from Pennsylvania for his questions.

Mr. WALKER. Thank you, Mr. Chairman. I'm primarily interested in money here, and I understand we've been through this but I want to clarify it and nail it down, going back to the chairman's original questions of where each of you came down on this question of second sourcing.

As I now understand it, as the figures have come out in the course of the hearing, we are talking about flight sets coming out of Morton Thiokol with the amortization costs and all of the various things to recover the transportation, refurbishment and so on, at a cost of somewhere in the vicinity of $18 to $19 million a set; and that we are talking about amortization costs on a second sourcing based upon the Hercules numbers originally. Are you with me so far?

Mr. BIEHLER. I don't know where to—you have to go through that with me one more time.

Mr. WALKER. Okay. Well, what I am doing here is I am taking all of the costs. I am taking the cost that was stated earlier. I think you gave an $18 million cost earlier, but that cost as I understand it came out in the hearing a little bit ago did not include amortizing the $160 million of cost for qualification. So that would add another $2 to $3 million of cost to your price. Plus, your figure did not include recovery, transportation and refurbishment, and so that would add somewhere in the vicinity of another $2 to $2.5 million to the price.

Mr. BIEHLER. I would like to make one clarification.

Mr. WALKER. Okay.

Mr. BIEHLER. I gave you a thought in there, my friend here pointed it out to me. When I told you that $18 million, and again that's new hardware, and they did factor in there what they thought the cost of recovery and refurbishment would be to put it on an apples-to-apples basis. And I was not aware of that and I think I misled you with that statement.

Mr. WALKER. Okay. Well. All right, well now——

Mr. BIEHLER. I'm sorry.

Mr. WALKER. Well, we do want to clarify that for the record. If in—your $18 million figure, then, included the $2 to $3 million of amortization costs for about $160 million of qualification; is that correct?

Mr. BIEHLER. No, it did not include the amortization cost. It did include——

Mr. WALKER. Oh. It included the recovery, transportation and refurbishment costs?

Mr. BIEHLER. It included our estimate of a factor for that.

Mr. WALKER. Okay. So the real figure here is that, if, in fact, we are talking about something in the vicinity of 55 flight sets between now and 1995, we are talking about an additional $2 to $3 million, then, on top of the $18 million figure that you quoted?

Mr. BIEHLER. That would be—that would be correct.

Mr. WALKER. So your figure—your figure, then, would be closer—I said 22 to 23. Your figure would really be closer to 20 to 21?

Mr. BIEHLER. Yes, sir, on that basis. I think that a lot of—in the acquisition, if the Government were to pay for the total development cost, and if you used those total development costs it would be 160 million. Then the proration should fall out like you stated it.

Mr. WALKER. Well, now let me see if I understand that. Am I being told that in order to qualify a second source that what we would have to do is pick up $160 million of costs for that qualification? Is that what you are saying to me?

Mr. BIEHLER. We've certainly been on record that there would have to be—the industry would participate, but not to the extent of funding the whole item itself.

Mr. WALKER. Okay. So. So now we are saying that the up-front cost to NASA for going to the second source would be the $160 million?

Mr. BIEHLER. There would be some share of that I am sure; yes, sir.

Mr. WALKER. Well, what share of it?

Mr. BIEHLER. At the time that we were talking about the involvement in the second sourcing of the solid rocket motors, the estimate at that point in time was roughly a hundred million dollars in non-reoccurring costs. There were, roughly, about $40 million of tooling and $60 million worth of hardware firing. And the industry offer at that point in time was to furnish the tooling, which would have been 40 million, and that would have left $60 million for NASA to participate in. Now the numbers have changed a little bit.

Mr. WALKER. So it's a 60-40 split. So if NASA's figures, if NASA's figures are right, 60 percent of 160 million—I'm having trouble doing the math in my head here, but it would be somewhere in the vicinity of a hundred million dollars of costs for NASA and the industry would pick up another 60 million.

On 55 flight sets, then, you're saying that you are going to have a cost, your figure was 18. To amortize that you would have to add at least 1 million. You would be at 19, which is about where, about the figure that Morton Thiokol says that they're at right now.

So that if I understand what we would be doing is, we would be spending a hundred million dollars of NASA money in order to qualify a second source for it, and what we would be getting is the motors, the solid rocket motors, at exactly the same cost.

Mr. BIEHLER. I can't disagree with that.

Mr. WALKER. I mean, the question becomes in a tight budget where we get that—where we get that hundred million dollars to go to that source that's not saving us any money? And my, the real question I was coming to was, there were some of you who testified here earlier that you thought that the second sourcing—in answer

to the chairman's question, was that the second sourcing was going to save us money.

Now those—I've got to tell you that even with the modifications we've gone through here those figures don't add up to any savings. In fact, it adds up to a hundred million dollars of costs that I'm not certain that we've got. Now can someone provide me with an explanation of this?

Mr. SIDES. If I may.

Mr. WALKER. Sure.

Mr. SIDES. Congressman, you might want to ask—I think there was another series of questions, and I believe both you and the Chairman were out of the room at the time, having to do with what is the estimated—I think the baseline for comparison was the 51–L cost achieved by the current supplier. So it might be of interest, because my impression of what I heard was that that cost today for the redesigned solid rocket motor is significantly higher. So maybe the baseline may have changed, and I think that would probably be a good question.

Mr. WALKER. Well, okay. Which baseline are we talking about? The baseline of the $18 million per set or the $160 million of qualification costs?

Mr. SIDES. Well, the qualification costs—well, the qualification costs is, I think what—we need to make sure we understand what configuration we're talking about.

Mr. WALKER. Okay.

Mr. SIDES. Are we talking about the redesigned solid motor?

Mr. WALKER. Okay.

Mr. SIDES. If we are talking about the redesigned solid—

Mr. WALKER. Well, let's—I think you're right we need to clarify it.

Mr. SIDES. Yes.

Mr. WALKER. Because my understanding of the original testimony was that for basis of comparison we were talking about a 51-L set because that's what everybody had worked up. That that's what everybody had worked up figures for. So I guess all of the analysis that I have just gone through here is for a 51-L set.

Mr. THIRKILL. Then I think your assessment is correct because I pointed out that the cost will be higher on the RSRM——

Mr. WALKER. Okay.

Mr. THIRKILL [continuing]. Because of the increased reliability, safety, inspection requirements that are being levied on us, and the additional support costs. We do not have an accurate number of what that's going to cost because we're not far enough into the program to have it fully defined. So we reverted to our costs for the 51-L configuration, and I think that that's the configuration that all of my cohorts——

Mr. WALKER. Okay.

Mr. THIRKILL [continuing]. Have made cost comparisons against.

Mr. WALKER. Well, let's make it on the record, and I think Mr. Sides raises an important point. That all of these figures that we have just given are not for the revised version; that all of those baseline costs are going to go up. But then I guess the question is, is there anything in that analysis of the 51-L sets that would change other than just go up a little bit in the, with the revised?

Mr. SIDES. I would only add one word, sir, of caution; and that is, using hypothetical models for determining what something that is going to be a different model is going to cost is a highly dangerous and sporty course, in my opinion.

Mr. WALKER. Okay. And that's a legitimate point. But the issue before this committee, and it is an issue that basically has to be resolved in this budget year, is the question of second sourcing, which is a policy question. And what I'm trying to do is look at the figures and decide whether or not as a matter of policy this committee wants to commit to the idea of second sourcing on those revised motors. Because if we don't do it this year, it becomes rather ludicrous to suggest that at some point in the future, down the road—we were only talking about going out to 1995 anyhow—that we would go to a second sourcing. So it becomes an issue for us this year.

And I think what I have just elicited here is that it may be a hundred-million-dollar issue for us this year, and that at a time of tight budget is certainly one of the things that we need to know and understand, is that the cost to NASA could be somewhere in the vicinity of a hundred million dollars.

Is there any disagreement with that analysis?

[No response.]

Mr. WALKER. Okay. Just for the record, I don't see any disagreement with that.

Mr. NELSON. Would the gentleman yield there?

Mr. WALKER. Yes, I'd be glad to.

Mr. NELSON. I want to make sure we nail this down, too.

Mr. WALKER. Be very glad to yield.

Mr. NELSON. What I've heard is that we're talking about, with the mathematics that Mr. Walker has just gone through, that the boosters would basically be the same cost whether or not there was a second source or not. Is that correct, Mr. Biehler?

Mr. BIEHLER. That, the analysis that Mr. Walker went through, during that period of time when you're amortizing those costs that would be true.

Mr. NELSON. We're talking about the cost to the U.S. Government.

Mr. BIEHLER. During that period of time, I believe—is that right, Mr. Walker—that you amortized those costs, and I believe you picked a 55 motor, was it?

Mr. WALKER. Yes. Well, it appeared to me that you're talking about between now and 1995 probably a 55-set rate, and so I picked that. And it appears as though that the cost for those 55 sets would be about exactly, about exactly the same.

Mr. NELSON. If the gentleman would further yield.

Mr. WALKER. Sure.

Mr. NELSON. When I asked in my little survey at the beginning of this hearing whether or not you agreed or disagreed with NASA that it would cost more, Mr. Sides, you said that you disagreed with NASA, as had Mr. Biehler. And then I asked Mr. Biehler: Do you think that second sourcing would save the Government money on a flight rate of 16 per year? And he said yes. And then I asked him which—I said: Do you think that second sourcing would save

the Government money at a flight rate of 12 per year? And he said yes.

Now, before I get my question to you, let me ask you, Mr. Biehler, how can you reconcile that answer and now this information?

Mr. BIEHLER. Well, what we were talking about doesn't—I think that we've made an assumption here that in 1993 there is going to be a different motor.

Mr. WALKER. No. By '95, I think.

Mr. BIEHLER. Well, '95, whatever the time frame is—and I was responding to you that in the event there is not an advanced solid rocket motor, then over the life of the Shuttle program competition would save the Government money. Certainly, if you come in and brought back into a shorter period of time, or 1993, it would not amortize off, nor would it be a good idea to second source the motor if, in fact, there is an advanced solid rocket motor in the plan and moving forward.

Mr. NELSON. Okay. I think that's an important point to make, then, and I don't think that that was clear earlier.

Mr. WALKER. That's right.

Mr. NELSON. Your answers to my questions at the outset of this hearing were predicated on the fact that there would not be an advanced solid rocket motor?

Mr. BIEHLER. Well, yes, sir, I believe that was the frame I was ref—right.

Mr. NELSON. Okay. And so what you're saying is that you're really not going to save any money on second sourcing the present SRM redesign if, in fact, a new advanced solid rocket motor is going to kick in in 1994 or 1995?

Mr. BIEHLER. I believe that would be true, sir.

Mr. NELSON. Okay. Is there anybody here who disagrees with that? Mr. Sides?

Mr. SIDES. I would like to comment, if I may, because I completely agree with the answer you were just given. That's my answer, too.

But also I want to make sure that the chairman and the committee understands that my recommendation, our recommendation was on the leader/follower concept that it would be advisable for NASA in their solicitations for the advanced solid rocket motor and for the—to consider in their solicitation for the redesigned solid rocket motor an alternate approach of a leader/follower concept to deal with that very issue. The issue that, if there is not funding available for the advanced motor, that there is an acquisition strategy in place to deal with the fact that the redesigned motor is going to continue for many years ahead. And I would submit that would be wisdom on the part of the Government to at least solicit a proposal to have that as an option to consider.

Mr. NELSON. Thank you for yielding.

Mr. WALKER. Yes, Mr. Chairman.

Okay. I think the one final thing, though, that we need to clarify here is, because there are—there would be some costs to go into second sourcing, let's say it's somewhere in the range of a hundred million dollars. Okay. The question then becomes what would we buy for that hundred million dollars? It seems to me the one thing

that we would buy for that hundred million dollars that the committee may want to consider is the fact that we would be buying a separate line of production that would give us a backup capability.

So I guess, Mr. Thirkill, what I need to know from you is, if you had an industrial accident of some sort, a major kind of calamity in your plant that knocked you completely out of production, producing the RSRM at a steady rate, as a sole source, then how long would it take you to get back into production?

Mr. THIRKILL. Well, I'll be back into production as soon as the incident investigation is completed, and then that normally takes no more than a month on incidents that I've been involved in. Because my facility is fully adequate to support 24 launches a year, we do not anticipate operating in excess of 12. My facility is designed such that I'm not going to lose the whole facility at one time unless the Russians decide to drop a bomb on it. And we historically or traditionally design our facilities so that if we do have a safety incident we lose only a portion of that facility. And all of my compatriots here do exactly the same thing.

Our facility is laid out, we have 10 casting pits that we cast motors in. We had an incident in a casting pit and we lost one casting pit that we were casting in and an adjacent pit that had a live segment in it that got ignited, but we were still able to maintain operation in five backup pits. They would be backup pits now at a rate of 12. We have four mixers dedicated to the SRM program with a fifth coming on line later this year, if we lose a mixer. We require three to support the casting rate that is required to maintain segments.

So we are not going to go out of business because of an incident unless somebody comes in and sabotages 10 casting pits, 5 mixers and the rest of the facility, you know, simultaneously, and I don't see that as a viable incident. Now there may be some disagreement about that.

Mr. WALKER. I was going to say, I guess what I need to know from the rest of the panel is, are there any of you who disagree with that analysis? Mr. Crosby?

Mr. CROSBY. Well, I would just like to comment that I am slightly familiar with the arrangement that has just been described at the Thiokol plant, and I completely agree with the gentleman's comments.

Mr. WALKER. So, just to clarify. If I understand you correctly, you don't believe that there would be any time, even given a significant accident, that you would be down for more than a month?

Mr. THIRKILL. That is correct, at a rate of roughly 12 a year because I've cut my plant capacity in half. If I go, the most severe incident that I could have would put one row of casting pits out of operation. It's going to take probably a month of an investigation panel to come in and assess the cause of the incident. And when we have an incident like that we shut operations down until we feel we've pretty firmly identified what the cause was, and I think that again is typical in our industry when you have an incident. And again, incidents are expected. That's why we design and lay out the facilities the way we do. We are involved in a hazardous operation. Handling the materials that we handle is hazardous. And that, again, is a tradition in our business.

But at a rate of 12 per year, we would not be down any longer than it would take to conclude the investigation of the incident, and that is relatively typically a month.

Mr. WALKER. Thank you.

Mr. NELSON. Mr. Hayes?

Mr. HAYES. The gentleman from Pennsylvania I think has made a good point but I don't think it's complete. I don't disagree with him. In fact, I think that it's an underestimate. You can't amortize per unit. And I wonder if any of you disagree with that. You can't take 160 to 200 million and amortize per unit. That's amortizing principal only and over no term.

If we impose instead a term amortization on this and then realize that we're talking about Government funding and bonded indebtedness and therefore look at bond markets and take quotes, it's not going to be 3 million a unit; it's going to be 7. And I assure you that that's using a generous term which probably ought not to be applied. It probably, if you were doing it in your business, you would look at a very much accelerated term and you would be looking at huge per unit differences—not 3.

And I think it's just important to add that on the record and to say that I appreciate the gentleman from Pennsylvania raising the issue, and I've gotten an education now in the way that some of these computations are made without amortization.

Mr. WALKER. If the gentleman would yield. He makes an excellent point. I am not capable of doing that higher mathematics here on my little pad, so I thank the gentleman.

Mr. CROSBY. If I could just comment that I appreciate the opportunity to sit here and now and listen to this discussion since we have felt and have taken a position for over a year that there was a lack of economic viability in this idea of competing these current boosters in view of the potential for a redesign activity, and I am very pleased to see that it's out in the open at this point.

Mr. NELSON. Mr. Brown, how do you verify the quality, and thus the burning rate, of the propellant when it is mixed on a continuous versus a batch process? How do you ensure and verify?

Mr. BROWN. We've had a new system called FTIR, which is Fourier Transform Infrared Reactive method, under development as a program in our company; and we feel it is at the stage now where it can be applied to a continuous process. We currently are in a verification mode on that new inspection process with the Rocket Propulsion Laboratory, and we are making active comparisons now on our current production program on the Peacekeeper.

We're taking the Peacekeeper program, which is done on a batch basis, where samples of propellant are taken aside and mechanical properties are checked and burning rate is checked, and all those things are checked on a sample-by-sample basis, and we're applying this continuous checking method along with that so that we can make direct comparisons between the way that we're doing it now and this new method that would be applied to a continuous process.

We have high confidence that this is a system that's going to be—that's going to, essentially, have a data base available within a few months to demonstrate the adequacy of the method, so that it can be done in real time as the propellant is flowing down a pipe.

Mr. NELSON. Okay. Let me get all of your opinion on this. If the advanced SRM were not approved, then what is the next best alternative? Let me go right down the line. Mr. Brown?

Mr. BROWN. If the advanced motor is not approved, which, of course, is against our desires, then I think that the concept of bringing on two sources is a good way to proceed and I think the leader/follower approach that has been discussed is a good method to accomplish that; to bring the second man on and qualify him, and, perhaps, get the original contractor involved in the qualification of the second man. And then once he is qualified, then on forthcoming procurements to essentially put not the program but put a sharing, part of the program up for grabs and get competitive bids once a man is qualified.

Mr. NELSON. Mr. Crosby?

Mr. CROSBY. If an advanced motor is not approved, I think the first thing that should be done is to wait until we are able to project a realistic flight rate with the redesigned boosters, which we are convinced will remain at somewhere in the 6- to 12-flights-per-year region. And I would suggest that the second best alternative might very well be to proceed immediately with the design of an improved expendable launch vehicle to accommodate the needs of the country in terms of space launch capability.

The third best alternative, I guess I would agree with Mr Brown's idea that—assuming that a competitive environment was desirable and there were reasonable flight projections, that a leader/follower approach might be the most economical from that point. Select a—hold a competition, select a follower and let him become qualified to produce along with Thiokol.

Mr. NELSON. Mr. Biehler?

Mr. BIEHLER. In the event there is not an advanced solid rocket motor, then I would agree with Mr. Brown from Aerojet that we should proceed immediately to second sourcing the existing thing—when I say immediately, as soon as it's applicable—and that a leader/follower arrangement would again be an approach that should be looked at.

Mr. NELSON. Mr. Sides?

Mr. SIDES. Atlantic Research recommended in the pre-Challenger request for information that NASA came out with that—we suggested the leader/follower concept at that point in time, and what I see is that if the advanced motor is not funded, really that puts NASA back into the pre-Challenger acquisition-type environment with the redesigned solid rocket motor. Therefore, certainly, we would strongly recommend that the number one alternative be the pursuit of a leader/follower concept along the lines that we had originally recommended and that Mr. Brown and Mr. Crosby—I think Mr. Crosby endorsed it as his number three recommendation——

Mr. CROSBY. That's correct.

Mr. SIDES [continuing]. And Mr. Biehler have suggested.

Mr. NELSON. Mr. Thirkill?

Mr. THIRKILL. I think that if the RSRM is—continues and there is no advanced SRM developed, I think that competition should be employed on the RSRM when it makes sense and it's economical and achieves a cost savings for the Government.

Mr. NELSON. That means you favor second sourcing or you're saying you don't know?

Mr. THIRKILL. I favor the development of second sources if they are cost effective and save money. And when the flight rate builds up using the RSRM, right now my feeling is that when you get above 24, which is our capability, 24 flights per year, then clearly you should go outside rather than expand the facility at our place, although we do have the capacity to go higher. But I'm confident that the costs there, it may be just as well off to go someplace else as to remain where we are. But until you get to the point that it is an economical, viable thing to do, having an alternate or second source doesn't make any sense.

Mr. WALKER. The subcommittee would be very interested in knowing when you think we are going to get past 24 flights a year.

Mr. THIRKILL. I do not have that insight, sir.

Mr. HAYES. It's the day we amortize the 200 million.

Mr. THIRKILL. Well, I, you know, I don't have the capability to forecast the future. I've never been one of these people that had any ability to do that. I continue to be amazed that we have the jet aircraft running around this country and the world that we have today because I would surely not have been capable of making that forecast when I first got on my first jet aircraft years ago.

But, you know, if the Space Station goes and if the Heavy Launch Vehicle goes and if it is a Shuttle-derived vehicle, we may very well see in the future the requirement for 24 launches a year; but that is going to be after my time. But I would like to leave that as a legacy for the people that follow me.

Mr. NELSON. Any further questions from the committee? Or the staff?

[No response.]

Mr. NELSON. Okay. Without objection, we will insert in the record the commentary that Mr. Beuchner asked us, questions and answers from the Governmental Operations Committee.

[The information follows:]

# EXCERPT SUBMITTED BY MR. BUECHNER FROM GOVERNMENT OPERATIONS HEARING 7/31/86

## HEARING

BEFORE A

SUBCOMMITTEE OF THE

## COMMITTEE ON GOVERNMENT OPERATIONS HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

JULY 31, 1986

Printed for the use of the Committee on Government Operations

HERCULES RESPONSE TO PREPARED QUESTIONS

Q. 4) HOW MANY ROCKET MOTORS WOULD YOU HAVE TO MANUFACTURE PER YEAR TO ACHIEVE A REASONABLE RETURN ON YOUR INVESTMENT UNDER THE GROUND RULES AS ANNOUNCED BY NASA? COULD YOU ESTABLISH PRODUCTION CAPACITY FOR A GUARANTEE OF 40 MOTORS, WITH NO ASSURANCE OF ANY FUTURE PURCHASES? IF NASA WERE TO DELETE THE REQUIREMENT THAT THE SECOND SOURCE USE THIOKOL NOZZLES, WOULD THAT CHANGE YOUR ANSWER REGARDING THE NUMBER OF MOTORS YOU WOULD HAVE TO PRODUCE IN ORDER TO ACHIEVE A REASONABLE RETURN ON INVESTMENT? IF SO, HOW?

A. The NASA ground rules established that the second source contractor provide the entire cost for qualification, in our case $100 million. Also, the second source supplier would have to compete with the incumbent at the same time that he would recover this up front expenditure of $100 million, and in addition would not have the benefit of nozzle sales. Under these ground rules, using the following assumptions:

Qualification costs equally split over 3 years totaling $100 MM
Motor price without nozzle (15 % fee included in price) as shown
Cost of capital = 9.5%

| Production Rate Motors/Year | Ave Price Per Motor $ Millions | Total Motors Produced to Break Even |
|---|---|---|
| 20 | 6.3 | 464 |
| 28 | 5.9 | 398 |
| 36 | 5.8 | 398 |

If only 40 motors were purchased under these conditions and ground rules, Hercules would not be able to recover the $100 MM investment let alone achieve a reasonable return, unless a surcharge was added to each motor for cost recovery. However, this would then put the second source in a noncompetitive position for the 40 motors, and according to the ground rules would eliminate him from participation from even the buy of 40.

The production of nozzles by the second source will provide significantly greater savings to NASA since the nozzle cost is approximately 21% of the total motor cost. The additional sales generated by second source nozzle production will also improve the return on investment outlook for the second source as follows:

| Production Rate Motors/Year | Ave Price Per Motor $ Millions | Total Motors Produced to Break Even |
|---|---|---|
| 20 | 6.1 | 303 |
| 28 | 7.5 | 308 |
| 36 | 7.4 | 296 |

The limitation to only 40 production motors continues to make the $100 million qualification program investment unattractive unless NASA provides for a special investment payback surcharge outside of the incumbent/second source competition for production split.

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Mr. NELSON. All right. If there's no further business, gentlemen, thank you for a most productive session.

The meeting is adjourned.

[Whereupon, at 5:07 p.m., the subcommittee was adjourned, to reconvene subject to the call of the Chair.]

# APPENDIX

Responses to Pre-Authorization Questions Submitted by the Subcommittee on Space Science and Applications (Chrm. Nelson).

QUESTION A-1:

Please furnish the following tabulation, by major program, for the FY 1988 budget request:

a. the original recommended budget to OMB
b. the adjustments made
c. the submission to Congress
d. brief comment on the adjustments made, i.e., a description of corresponding program impacts or changes
e. the comparative FY 1987 operating plan figure
f. please assign an agency priority to those programs requested from OMB but not presented to Congress.

ANSWER A-1:

See Table A

TABLE A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1988 BUDGET

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | △ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| RESEARCH AND DEVELOPMENT | 3127.7 | 4106.4 | -483.2 | 3623.2 | |
| Space Station | 420.0 | 1055.0 | -288.0 | 767.0 | Reduction consistent with early development schedule changes. |
| Space Transportation Capability Development | 495.5 | 570.4 | -1.8 | 568.6 | Adjustment to payload operations funding. |
| Space Science and Applications | 1552.6 | 1616.7 | -108.4 | 1508.3 | |
| Space Science | 983.4 | 987.4 | -38.4 | 949.0 | |
| Physics and Astronomy | 552.8 | 605.5 | -38.4 | 567.1 | |
| Hubble Space Telescope Development | 101.3 | 98.4 | 0.0 | 98.4 | |
| Gamma Ray Observatory Development | 50.5 | 49.1 | 0.0 | 49.1 | |
| Spacelab P/L Dev. & Mission Mgmt. | 98.1 | 96.8 | -1.4 | 95.4 | Adjustment to shuttle payload funding. |
| High Resolution Solar Obs Dev | 0.0 | 12.0 | -12.0 | 0.0 | Deletion of funds for proposed new initative. |
| Explorer Development | 56.7 | 60.3 | 0.0 | 60.3 | |
| Mission Ops. & Data Analysis | 125.7 | 128.1 | 0.0 | 128.1 | |
| Research and Analysis | 53.4 | 85.1 | -25.0 | 60.1 | Deletion of $25.0M for AXAF Pathfinder ATD. |
| Suborbital Program | 75.1 | 75.7 | 0.0 | 75.7 | |
| Life Sciences | 72.2 | 74.6 | 0.0 | 74.6 | |
| Life Sciences Flight Experiments | 30.4 | 32.9 | 0.0 | 32.9 | |
| Research and Analysis | 41.8 | 41.7 | 0.0 | 41.7 | |
| Planetary Exploration | 358.4 | 307.3 | 0.0 | 307.3 | |
| Galileo Development | 71.2 | 55.3 | 0.0 | 55.3 | |
| Ulysses | 10.3 | 10.8 | 0.0 | 10.8 | |
| Magellan | 92.6 | 59.6 | 0.0 | 59.6 | |
| Mars Observer | 35.8 | 29.3 | 0.0 | 29.3 | |
| Mission Ops. & Data Analysis | 80.0 | 77.0 | 0.0 | 77.0 | |
| Research and Analysis | 68.5 | 75.3 | 0.0 | 75.3 | |

QUESTION A-2:

Please furnish the following information, by NASA Center and by major program, for the FY 1988 budget request:

a. original Center request to NASA Headquarters
b. the adjustments made
c. brief comments on adjustments made
d. the submission to Congress as allocated by Center
e. the comparative FY 1987 operating plan figure, by Center

ANSWER A-2:

Material to be submitted at a later date.

QUESTION A-3:

Please furnish by major line item, the NASA operating plan for FY 1986 and FY 1987 with comments on adjustments, if any.

ANSWER A-3:

See Table B

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | △ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| Space Applications | 569.2 | 629.3 | -70.0 | 559.3 | |
| Solid Earth Observations, | 75.6 | 76.8 | 0.0 | 76.8 | |
| Shuttle/Spacelab Payload Development | 21.6 | 21.1 | 0.0 | 21.1 | |
| Applied Research, Data Analysis and Related Activities | 54.0 | 55.7 | 0.0 | 55.7 | |
| Environmental Observations | 320.9 | 393.8 | 0.0 | 393.8 | |
| Upper Atmospheric Research Satellite | 114.2 | 95.4 | 0.0 | 95.4 | |
| Shuttle/Spacelab Payload Development | 12.6 | 19.4 | 0.0 | 19.4 | |
| Applied Research, Data Analysis and Related Activities | 142.8 | 141.3 | 0.0 | 141.3 | |
| Scatterometer | 32.9 | 22.7 | 0.0 | 22.7 | |
| Ocean Topography Experiment | 19.8 | 90.0 | 0.0 | 90.0 | |
| Global Geospace Science | 0.0 | 25.0 | 0.0 | 25.0 | |
| Materials Processing | 67.9 | 45.9 | 0.0 | 45.9 | |
| Space Communication | 103.5 | 90.5 | -70.0 | 20.5 | |
| Search and Rescue Transition | 1.0 | 1.3 | 0.0 | 1.3 | |
| Adv. Comm. Tech. Satellite Development | 85.0 | 70.0 | -70.0 | 0.0 | Consistent with FY 1987 rescission. |
| Applied Research, Data Analysis and Related Activities | 17.5 | 19.2 | 0.0 | 19.2 | |
| Information Systems | 20.3 | 22.3 | 0.0 | 22.3 | |
| Commercial Programs | 41.3 | 54.0 | 0.0 | 54.0 | |
| Technology Utilization | 15.7 | 18.3 | 0.0 | 18.3 | |
| Commercial Use of Space | 25.6 | 35.7 | 0.0 | 35.7 | |
| Aeronautical Research and Technology | 376.0 | 385.0 | -10.0 | 375.0 | |
| Research and Technology Base | 272.9 | 285.2 | 0.0 | 285.2 | |
| Systems Technology Programs | 103.1 | 99.8 | -10.0 | 89.8 | Deletion of funds for High Alpha Technology |
| Transatmospheric Research and Technology | 65.0 | 66.0 | 0.0 | 66.0 | |

| | FY 1987 CONG BUDGET | FY 1988 OMB BUDGET | Δ | FY 1988 CONG BUDGET | |
|---|---|---|---|---|---|
| Space Research and Technology | 171.0 | 325.0 | -75.9 | 250.0 | |
| Research and Technology Base | 133.6 | 115.9 | 0.0 | 115.9 | Reduction of funds for CSTI program. |
| Systems Tech Program | 37.4 | -- | -- | -- | |
| CSTI Program | -- | 156.1 | -20.0 | 136.1 | |
| Pathfinder | -- | 55.0 | -55.0 | 0.0 | Deletion of augmentation directed at enabling technology for future missions. |
| Safety, Reliability and Quality Assurance | 0.2 | 16.2 | 0.0 | 16.2 | |
| Tracking and Data Acquisition Advanced Sys | 17.1 | 18.1 | 0.0 | 18.1 | |
| SPACE FLIGHT, CONTROL, AND DATA COMMUNICATION | 5015.0 | 4064.3 | 0.0 | 4064.3 | |
| Shuttle Production & Capability Development | 1985.1 | 1229.6 | 0.0 | 1229.6 | |
| Replacement Orbiter | 2100.0 | -- | -- | -- | |
| Space Shuttle Operations | 1047.9 | 1885.8 | 0.0 | 1885.8 | |
| Space and Ground Networks, Communications and Data Systems | 882.9 | 948.9 | 0.0 | 948.9 | |
| RESEARCH AND PROGRAM MANAGEMENT | 1425.9 | 1634.6 | -36.0 | 1598.8 | -30.4M for new initiatives and augmentations, -5.6M reestimate of FERS. |
| CONSTRUCTION OF FACILITIES | 166.3 | 219.6 | -24.1 | 195.5 | -17.8M for Large Spacecraft Lab at LaRC; -6.3M for Mods to Atmospheric Reentry Materials and Structures Evaluation Fac at JSC. |
| TOTAL NASA | 10534.0 | 10024.3 | -543.3 | 9481.0 | |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 AND FY 1987 OPERATING PLANS
BY BUDGET LINE ITEM
(Dollars in Millions)

| | FY 1986 | FY 1987 |
|---|---|---|
| RESEARCH AND DEVELOPMENT | 2619.3 | 3127.7 |
| Space Station | 206.3 | 420.0 |
| Space Transportation Cap Dev | 403.9 | 495.5 |
| Physics and Astronomy | 569.3 | 552.8 |
| Life Sciences | 66.1 | 72.2 |
| Planetary Exploration | 353.6 | 358.4 |
| Space Applications | 487.5 | 569.2 |
| Technology Utilization | 10.6 | 15.7 |
| Commercial Use of Space | 16.2 | 25.6 |
| Aeronautical Research and Technology | 337.3 | 376.0 |
| Transatmospheric Research and Technology | 0.0 | 45.0 |
| Space Research and Technology | 151.4 | 171.0 |
| Safety, Reliability and Quality Assurance | 7.6 | 9.2 |
| Tracking and Data Advanced Systems | 15.5 | 17.1 |
| SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS | 3665.9 | 5815.0 |
| Shuttle Prod and Operational Capability | 1365.3 | 1005.1 |
| Replacement Orbiter | 0.0 | 2100.0 |
| Space Transportation Operations | 1640.2 | 1847.0 |
| Space and Ground Network, Communications and Data Systems | 660.4 | 862.9 |
| RESEARCH AND PROGRAM MANAGEMENT | 1241.3 (1) | 1466.5 |
| CONSTRUCTION OF FACILITIES | 137.5 | 166.3 |
| S/TOTAL NASA BUDGET | 7764.0 | 10575.5 |
| PAY RAISE AND FERS | --- | -41.5 |
| TOTAL NASA | 7764.0 | 10534.0 (2) |

(1) Reflects actuals for FY 1986
(2) The FY 1987 amounts shown by budget line item are consistent with the Operating Plan transmitted to the Committees on 12/8/86 except in the following areas:
- Space Transportation Cap Dev reflects a net decrease of $12M which is the result of reduced Upper Stage requirements offset by an augmentation to Advanced Programs for NASA/DOD studies on future launch vehicle requirements.
- Physics and Astronomy reflects a net increase of $7.5M primarily to fund definition and planning activities for payloads to be flown on the Space Station.
- Space Applications increased a net of $4.5M which is the result of a reduction in Scatterometer due to a delay in the launch date offset by an augmentation in Materials Processing to support definiton activity for Space Station hardware development.
- Research and Program Management includes $41.5M for the impact of the Pay Raise and FERS. The source of the funding to cover this impact has not been determined.

QUESTION A-4:

Please provide a tabulation of projected total costs of all major programs, including (please include initial estimates for budgeted new starts):

a. original estimate date and amount
b. current estimate
c. NASA's estimate of what portion of any increased cost may be due to inflation

ANSWER A-4:

See Table C

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ESTIMATED TOTAL PROJECT COST
(in millions of dollars)

TABLE C

| | Original Development Estimate | | Current Estimate |
|---|---|---|---|
| | Date | Range | |
| Global Geospace Science Mission | 1/87 | 390-440 | |
| Ocean Topography Experiment | 1/86 | 380-430(b) | 380-430(d) |
| Hubble Space Telescope Development | 2/78 | 565-611(a) | 1400-1500(e) |
| Ulysses Development | 1/83 | 120-140 | 160-180(g) |
| Ulysses Mission Ops & Data Analysis | 1/83 | 20-30 | 40-50(e) |
| Gamma Ray Observatory (GRO) Development | 1/83 | 395-435 | 508-540(d) |
| GRO Mission Ops & Data Analysis | 1/83 | 30-40 | 50-60(e) |
| Galileo Development | 1/83 | 650-700 | 890-920(f) |
| Galileo Ops & Data Analysis | 1/83 | 180-210 | 450-500(e) |
| Magellan Mission Development | 1/83 | 320-350 | 425-465(f) |
| Magellan Mission Ops & Data Analysis | | 30-50 | 85-100(e) |
| Tethered Satellite | 1/83 | 40-50(b) | 60-70 |
| Upper Atmosphere Research Satellite (UARS) | 1/84 | 630-700(b) | 730-780(d) |
| Mars Observer | 1/84 | 300-375(b) | 380-420(d) |
| Scatterometer | 1/84 | 120-135(b) | 140-160(c) |
| Orbital Maneuvering Vehicle | 1/85 | 375-450(b) | 450-500(d) |

(a) Original Space Telescope estimate, which supported a late 1983 launch, was stated in FY 1978 budget dollars, to be updated annually; this estimate has been updated to reflect real year dollars. The increase reflected by the current estimate is due to continuing development problems and a series of launch slips from late 1983 to the second half of 1988.

(b) Planning estimate; development estimate not yet available.

(c) Launch date uncertain due to change in spacecraft carrying instrument.

(d) This estimate has been increased due to the launch slip caused by the Shuttle flight standdown as a result of the 51-L accident.

(e) This estimate has been increased due to the additional years of operations activity required as a result of the launch slip caused by the 51-L accident.

(f) This estimate has been increased due to the launch slip resulting from the Shuttle flight standdown as well as hardware, software and mission design mods to accommodate the change from Centaur to the Inertial Upper Stage (IUS).

(g) This estimate has been increased due to the launch delay resulting from the Shuttle flight standdown as well as hardware, sortware and mission design mods required to accommodate the change from Centaur to the IUS/PAM-S upper stage configuration.

QUESTION A-5:

Please provide an analysis of the effect of inflation on the aggregate buying power of NASA.

ANSWER A-5:

See Table D

National Aeronautics and Space Administration

EFFECT OF INFLATION ON NASA BUDGET
COMPARATIVE PURCHASING POWER INDICES FY 1973 - 1988

TABLE D

| | GNP Price[1] Deflator (%) | NASA Aerospace[2] Price Deflator (%) | Budget Outlays - Millions of Dollars Actuals | Constant FY 1973 [3] | Constant FY 1973 [4] |
|---|---|---|---|---|---|
| FY 1973 | 100.0 | 100.0 | 3315 | 3315 | 3315 |
| FY 1974 | 91.7 | 93.3 | 3256 | 3037 | 2984 |
| FY 1975 | 83.5 | 84.2 | 3267 | 2751 | 2727 |
| FY 1976 | 78.5 | 77.2 | 3669 | 2834 | 2879 |
| FY 1977 | 73.5 | 71.2 | 3945 | 2809 | 2901 |
| FY 1978 | 68.5 | 66.0 | 3983 | 2630 | 2729 |
| FY 1979 | 62.9 | 60.3 | 4197 | 2531 | 2641 |
| FY 1980 | 57.7 | 54.5 | 4852 | 2643 | 2801 |
| FY 1981 | 52.6 | 49.1 | 5426 | 2665 | 2856 |
| FY 1982 | 49.5 | 44.9 | 6035 | 2710 | 2985 |
| FY 1983 | 47.6 | 42.3 | 6664 | 2820 | 3172 |
| FY 1984 | 45.9 | 40.0 | 7048 | 2819 | 3232 |
| FY 1985 | 44.4 | 38.4 | 7317 | 2809 | 3249 |
| FY 1986[5] | 43.2 | 37.2 | 7403 | 2757 | 3197 |
| FY 1987[5] | 41.8 | 36.0 | 7587 | 2732 | 3172 |
| FY 1988[5] | 40.4 | 34.8 | 9545 | 3321 | 3856 |

1/ Economic Indicators, December 1986, year over year growth.
2/ Reflects labor intensive nature of NASA purchases using aerospace related inflation data.
3/ Constant FY 1973 outlays calculated using the NASA Aerospace Price Deflator.
4/ Constant FY 1973 outlays calculated using the GNP Price Deflator.
5/ Current estimates.

QUESTION A-6:

Please furnish, by major program, the unobligated balance of funds for FY 1986 and FY 1987 and the actual or estimated carry over as of January 15, 1987.

ANSWER A-6:

See Table E

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
UNOBLIGATED BALANCES BY MAJOR PROGRAM 9/30/86, 12/31/86, & 9/30/87
(Millions of Dollars)

TABLE 3

| APPROPRIATION/PROGRAM | FY 1986 & PRIOR UNOBLIGATED BALANCE 9/30/86 | FY 1987 UNOBLIGATED BALANCE 12/31/86 | ESTIMATED UNOBLIGATED BALANCE 9/30/87 |
|---|---|---|---|
| RESEARCH AND DEVELOPMENT | 368.7 | 2,582.1 | 160.8 |
| SPACE STATION | 18.8 | 362.9 | 21.0 |
| SPACE TRANSPORTATION CAPABILITY DEVELOPMENT | 114.0 | 435.2 | 57.4 |
| PHYSICS AND ASTRONOMY | 80.6 | 464.3 | 20.2 |
| LIFE SCIENCES | 4.1 | 63.4 | 3.6 |
| PLANETARY EXPLORATION | 24.5 | 268.8 | 17.9 |
| SPACE APPLICATIONS | 70.7 | 468.4 | 7.8 |
| COMMERCIAL PROGRAMS | 9.2 | 37.8 | 2.0 |
| SPACE RESEARCH AND TECHNOLOGY | 25.7 | 125.4 | 6.5 |
| TRANSATMOSPHERIC VEHICLE RESEARCH & TECHNOLOGY | 0.0 | 45.0 | 2.2 |
| AERONAUTICAL RESEARCH AND TECHNOLGOY | 16.5 | 288.0 | 10.8 |
| SAFETY, RELIABILITY AND QUALITY ASSURANCE | 2.5 | 8.4 | 2.6 |
| TRACKING AND DATA ADVANCED SYSTEMS | 2.1 | 14.5 | 0.8 |
| SPACE FLIGHT, CONTROL & DATA COMMUNICATIONS | 450.8 | 4,823.3 | 2,503.0 |
| SHUTTLE PRODUCTION & OPERATIONAL CAPABILITY | 342.7 | 2,872.5 | 2,374.5 |
| SPACE TRANSPORTATION OPERATIONS | 31.0 | 1,411.2 | 41.3 |
| SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS | 77.1 | 539.6 | 87.2 |
| CONSTRUCTION OF FACILITIES | 61.7 | 158.3 | 79.8 |
| RESEARCH AND PROGRAM MANAGEMENT | 0.0 | 1,071.6 | 0.0 |
| TOTAL, NASA | 881.2 | 8,635.3 | 2,743.6 |

NOTE: DOES NOT REFLECT ACTS RESCISSION, PAY RAISE AND FERS.

QUESTION A-7:

In accordance with Rule XI, Clause 2(1)(4) of the Rules of the House of Representatives, the Committee is required to include in the report accompanying the NASA authorization bill an assessment of the impact of the legislation on inflation. Please provide the Committee with any information or reports which would be useful to the Committee in fulfilling this requirement.

ANSWER A-7:

In accordance with Rule XI, Clause 2(1)(4) of the Rules of the House of Representatives this legislation is assessed to have no adverse long-run inflationary effects on prices and cost in the operation of the national economy. NASA expenditures are labor intensive, with approximately 80 percent of spending directly for jobs and the remainder for materials. In FY 1987, NASA will employ about 21,800 civil servants and support about 143 thousand contractor and support services employees. Assuming a multiplier effect of 2.5, the total, short-run employment effect on the United States' economy in FY 1987 is about 412 thousand jobs. In FY 1988, NASA will employ 22,425 civil servants and support about 157 thousand contractor and support services employees. Assuming a multiplier effect of 2.5, the total short-run employment effect on the United States' economy in FY 1988 is about 450,000 jobs. This represents less than one-half of one percent of the total civilian labor force in the United States--too small to have a significant national effect. There could be some specific cases of industrial and regional employment and price changes influenced by NASA expenditures.

The most significant economic effects of NASA spending is the long-run productivity advance from new technologies developed for the space and aeronautics programs. Many NASA-sponsored advances in air and space transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses.

NASA is actively pursuing its role to expand the opportunities for private industry to gain access into space effectively and economically use space for commercial ventures. These expanded business opportunities have stimulated and are expected to continue to stimulate more productive, non-inflationary private sector economic growth, job creation and improve the United States competitive economic position in the world, e.g., improve United States trade balance.

QUESTION A-8:

Please provide a summary of the Space Shuttle operational capabilities that were originally proposed at the beginning of the program as compared to the operational capabilities which will exist with the current three orbiter fleet. This summary should include, but not be limited to, payload launch capability (ETR and WTR), flight rate capability, on-orbit stay time, cost per flight, and orbiter turnaround time. This summary should also include a schedule for planned performance improvements and the addition of the fourth orbiter.

ANSWER A-8:

| | Item | Originally Proposed | Current Plan |
|---|---|---|---|
| (1) | P/L Launch Capability | | |
| | ETR (160nm Due East) | 65,000 lbs. | 50,000 lbs. |
| | WTR (130nm 98°) | 32,000 lbs. | 18,000 lbs. |
| (2) | Flight Rate | 60 per year | 16 per year (4 orbiters) 12 per year (3 orbiters) |
| (3) | On-orbit Stay Time (Max) | 30 days | 9 days* |
| (4) | Cost-per-Flight | 34.5 million (1982 dollars) | 139.4 million (1982 dollars) (36 flights 1989-1991)*** |
| (5) | Orbiter Turnaround Time | 160 hours over 14 calendar days | 60 days** |
| (6) | On Orbit Repair | Yes | Yes |
| (7) | Intact Abort | Yes | Yes |
| (8) | Down Cargo | 32,000 lbs. | 24,000 lbs. |
| (9) | Crew Nominal | 4 | 5 |
| | Max | 10 | 7 |
| (10) | SRB Reuse | 20 | 20 |
| (11) | Standby Launch | | |
| | Standby Status | 24 hours | 24 hours |
| | Launch | 2 hours | 6.5 hours |

* Requires five cryo tanks (OV-102)

** 60 days within four years of return to flight. This is a target for nominal operations after return to flight. Turnaround for first flights will vary depending on the return to flight activities.

*** This comparison may not be entirely representative due to different assumptions involved in each calculation (i.e. flight rate)

STATUS:

- Fourth Orbiter delivery is estimated to be April 1991
- It is estimated that significant increases in payload launch capability are possible with performance enhancements. These include ascent design (requires flight data), 109 percent SSME throttle (requires demonstrated performance with new high pressure pumps), Block II SRB motor (3 year system certification effort), super light-weight External Tank (4 year design effort), Filament Wound Case, and stretched SRB (total system certification). These enhancements are being carefully considered.

QUESTION A-9:

Please provide a summary of the plan for production of the Replacement Orbiter vehicle including, initial cost estimates, current cost estimates, all changes made as a result of the accident and resulting recommendations, and the itemized costs associated with these.

ANSWER A-9:

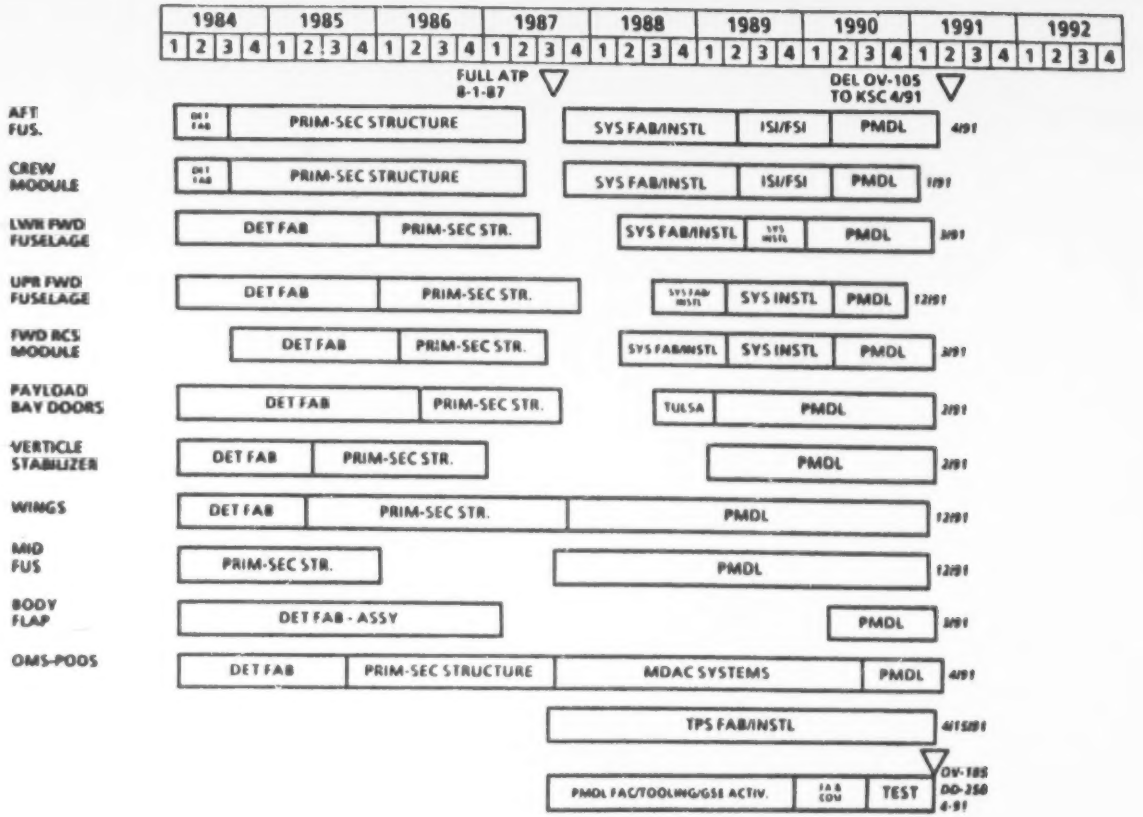
In February 1986, the initial cost for the Replacement Orbiter vehicle was estimated at $1.969. This estimate included the Rockwell Budget and Planning Estimate which projected a 42 month build schedule and a delivery date of September 1989. This projection was based on a March 1986, Authority to Proceed and the full use of Logistics spares. The estimate provided for the Rockwell Orbiter, engines, Orbiter support, and replacement of support hardware lost on 51-L.

The present estimate for the Replacement Orbiter is $2.1 billion. The build plan is now 45 months with an authority to proceed of August 1, 1987, and a delivery date of April 1991. The longer schedule is due to minimal borrowing from Logistics.

Changes from the OV-104 Orbiter which will be made to the Replacement Orbiter as a result of the accident and the resulting recommendations have yet to be fully defined; however, the expected cost impact on the Replacement Orbiter is small since the cost for the changes will be carried with the anomaly resolution cost and the recurring cost will not be significantly more than the current design. The procurement schedule and build and flow preliminary schedules are attached.

12-17-86 AH
MV 1160-1

# ORBITER 105 PRELIMINARY MASTER SCHEDULE



# REPLACEMENT ORBITER PROPOSAL ACTIVITY

| ITEM | DATE |
|---|---|
| REQUEST FOR PROPOSAL | 1/87 |
| PROPOSAL | 3/87 |
| FACT-FINDING COMPLETE | 5/87 |
| PRE NEGOTIATION POSITION TO HEADQUARTERS | 7/87 |
| NEGOTIATIONS COMPLETE | 7/87 |
| DEFINITIZED CONTRACT | 8/1/87 |

QUESTION A-10:

Please submit a full documentation of NASA's reimbursable obligations, by major program, and identify the source of these reimbursements. The documentation should be at the same level of detail as that for directly funded programs. (Ref. p. 34, Committee Report "National Aeronautics and Space Administration Authorization Act, 1987", September 16, 1986)

ANSWER A-10:

See Table F

FY 1988 BUDGET
RESEARCH AND DEVELOPMENT
REIMBURSABLE SUMMARY

| | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|
| SPACE STATION | 0.1 | 0.1 | -- |
| SPACE TRANSPORTATION CAPABILITY DEV | 206.5 | 116.0 | 117.7 |
| DOD | 191.8 | 101.9 | 110.0 |
| NOAA | 2.7 | 2.8 | 2.7 |
| Other Federal | 2.8 | 5.1 | 3.4 |
| Non-Federal | 9.7 | 0.4 | 1.6 |
| SPACE SCIENCE AND APPLICATIONS | 512.1 | 836.1 | 420.0 |
| PHYSICS AND ASTRONOMY | 11.6 | 13.9 | 13.0 |
| DOD | 7.2 | 10.3 | 9.5 |
| Other Federal | 0.4 | 1.3 | 1.2 |
| Non-Federal | 4.0 | 2.3 | 2.3 |
| LIFE SCIENCES | 0.8 | 0.4 | 0.4 |
| PLANETARY EXPLORATION | 0.2 | 0.1 | 0.2 |
| SPACE APPLICATIONS | 499.7 | 821.7 | 406.4 |
| DOD | 267.8 | 370.8 | 307.4 |
| NOAA | 217.2 | 226.5 | 83.0 |
| Other Federal | 7.8 | 16.4 | 10.0 |
| Non-Federal | 6.9 | 6.0 | 6.0 |
| COMMERCIAL PROGRAMS | 2.9 | 4.0 | 2.0 |
| DOD | 0.3 | 0.4 | 0.1 |
| Other Federal | 2.5 | 3.4 | 1.8 |
| Non-Federal | 0.1 | 0.2 | 0.1 |
| AERONAUTICAL RESEARCH AND TECHNOLOGY | 78.4 | 107.0 | 88.7 |
| DOD | 64.2 | 98.5 | 83.1 |
| Department of Transportation | 10.5 | 8.1 | 5.5 |
| Other Federal | 1.5 | 0.4 | 0.1 |
| Non-Federal | 0.2 | -- | -- |
| SPACE RESEARCH AND TECHNOLOGY | 10.5 | 13.0 | 13.7 |
| DOD | 3.5 | 8.8 | 9.3 |
| Department of Energy | 7.0 | 4.2 | 4.4 |
| SAFETY, RELIABILITY AND QUALITY ASSURANCE | 3.2 | 4.0 | -- |
| DOD | 3.2 | 4.0 | -- |
| ENERGY TECHNOLOGY | 77.9 | 45.0 | 27.2 |
| Department of Energy | 76.8 | 43.9 | 26.3 |
| Other Federal | -- | 0.5 | 0.3 |
| Non-Federal | 1.1 | 0.6 | 0.6 |
| TOTAL RESEARCH AND DEVELOPMENT | 889.8 | 919.2 | 689.3 |

FY 1988 BUDGET
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS
REIMBURSABLE SUMMARY

| | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|
| SHUTTLE PRODUCTION AND CAPABILITY DEV (DOD) | 364.9 | 105.1 | 134.8 |
| SHUTTLE OPERATIONS | 277.6 | -180.0 | 0.0 |
| DOD | 223.0 | -- | -- |
| NOAA | 35.0 | -35.0 | -- |
| Non-Federal | 19.6 | -145.0 | -- |
| EXPENDABLE LAUNCH VEHICLES | 230.4 | 236.0 | 70.7 |
| DOD | 181.0 | 164.5 | 70.7 |
| NOAA | 33.5 | 10.6 | -- |
| Non-Federal | 15.9 | 60.9 | -- |
| TRACKING AND DATA | 36.8 | 45.5 | 38.3 |
| DOD | 17.4 | 21.1 | 18.2 |
| NOAA | 14.2 | 15.5 | 16.1 |
| Other Federal | 2.5 | 4.0 | 2.1 |
| Non-Federal | 2.7 | 4.9 | 3.9 |
| TOTAL SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS | 909.7 | 206.6 | 243.8 |

QUESTION A-11:

Please provide a summary of those funding requirements necessary to return the Space Shuttle program to flight status.

ANSWER A-11:

The attached tables show the current estimates of actions which have been identified for anomaly resolution and related/ corrective actions and for implementation of recommendations of the Rogers Commission.

In general, the items carried under anomaly resolution/corrective actions are those required to permit the initial resumption of flights. Those carried as responsive to the Rogers Commission are the additional actions required to strengthen the system and to permit establishment of a safe and stable flight rate.

In general, the items included under Production and Operational Capability are discrete, non-recurring activities required to establish the necessary capabilities. The amounts shown under Shuttle Operations reflect the augmentation of manpower in launch and flight operations and related activities. The estimates show the total projections for the items under Shuttle Production Capability Development. The impact on Operations in future years will be determined as we acquire experience following resumption of flights. The requirements for funding in FY 1986/1987 are within the amounts appropriated for these years.

SPACE SHUTTLE FUNDING
FOR ACTIONS IN RESPONSE TO ROGERS COMMISSION
(MILLIONS OF DOLLARS)

| SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY | FY 1986/1987 | FY 1988 | BALANCE TO COMPLETE | TOTAL |
|---|---|---|---|---|
| ORBITER MODIFICATIONS (CATEGORY 2/3) | 8 | 48 | 74 | 130 |
| KSC RETURN TO FLIGHT STATUS MODIFICATIONS | 32 | 7 | 6 | 45 |
| REPLACE SRB INSULATION/ALTERNATE DESIGN | 18 | 17 | 6 | 41 |
| SHUTTLE CARRIER AIRCRAFT MOD KIT | 10 | 17 | 5 | 32 |
| SHUTTLE TRAINING AIRCRAFT (4TH) | -- | 2 | 21 | 23 |
| SHUTTLE MISSION SIMULATOR UPGRADES | 12 | -- | 32 | 44 |
| PROCUREMENT OF ADDITIONAL MAIN ENGINE | 7 | 19 | 20 | 46 |
| ORBITER SPARES ACCELERATION | 36 | 7 | -60 | -17 |
| FERRY TAIL CONE | 5 | -- | | 5 |
| SRB TEST STAND EQUIPMENT | 16 | -- | -- | 16 |
| FLIGHT SUPPORT SYSTEMS IMPROVEMENTS (WEATHER SYS, INTEGRATION, SOFTWARE, ETC.) | 19 | 6 | 33 | 58 |
| CREW ESCAPE SYSTEM STUDIES | 7 | -- | -- | 7 |
| CONTINGENCY FOR CREW ESCAPE, IMPLEMENTATION | 0 | 50 | 100 | 150 |
| TOTAL IN SHUTTLE PRODUCTION AND CAPABILITY DEVELOPMENT | 170 | 173 | 237 | 580 |
| ESTIMATED IMPACT ON SHUTTLE OPERATIONS FUNDING REQUIREMENT | (73) | 71 | 300-400 | |

SPACE SHUTTLE
ANOMALY RESOLUTION/CORRECTIVE ACTIONS
MILLIONS OF DOLLARS

| SHUTTLE PRODUCTION AND CAPABILITY DEVELOPMENT | ESTIMATE PRESENTED TO SENATE APPROPRIATION COMMITTEE (MAY 1986) | REVISED ESTIMATE BASED ON CURRENTLY IDENTIFIED ITEMS | | | |
|---|---|---|---|---|---|
| | | FY 1986/87 | FY 1988 | BALANCE TO COMPLETE | TOTAL |
| SALVAGE OPERATIONS | 15 | 17 | | | 17 |
| INVESTIGATIONS, TEST, ANALYSIS | 28 | 18 | | | 18 |
| CONTINUATION OF STRUCTURAL SPARES | 28 | 15 | | | 15 |
| MAIN PROPULSION TEST DELAY | 13 | 6 | 4 | 12 | 22 |
| EQUIPMENT KIT FOR ORBITER MODS FOR CENTAUR | 5 | 5 | | | 5 |
| SRM REDESIGN, FABRICATION TESTING | 250 | 229 | 61 | 11 | 301 |
| SRB REUSABILITY RECERTIFICATION AND INCREASED FLT INSTRUMENTATION | 12 | 30 | 15 | | 45 |
| CRITICAL ITEMS LIST CORRECTIONS | | | | | |
| FMEA/CIL REVIEWS | -- | 58 | -- | | 58 |
| MAIN ENGINE | 125 | 113 | 25 | | 138 |
| BOOSTER ASSEMBLY RECERTIFICATION | 15 | 40 | 6 | | 46 |
| ORBITER | 85 | 74 | 33 | 26 | 133 |
| CONTINGENCY | 50 | | | | |
| TOTAL IN SHUTTLE CAPABILITY DEVELOPMENT AND PRODUCTION | 626 | 605 | 144 | 49 | 798 |
| ADDITIONAL ITEMS UNDER SHUTTLE OPERATIONS | -- | 10 | 10 | | 20 |

QUESTION A-12:

Provide the following information with regard to support contractors:

a. the number of employees of support contractors by Center and major program
b. the associated employee cost by Center and major program

ANSWER A-12:

See Table G

TABLE G

| | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|
| | Contractor Workyears | Employee Costs | Contractor Workyears | Employee Costs | Contractor Workyears | Employee Costs |
| JOHNSON SPACE FLIGHT CENTER | 761 | 28,245 | 784 | 29,766 | 789 | 32,758 |
| KENNEDY SPACE FLIGHT CENTER | 1,421 | 70,937 | 1,442 | 73,450 | 1,543 | 79,724 |
| MARSHALL SPACE FLIGHT CENTER | 501 | 19,262 | 504 | 20,403 | 504 | 22,243 |
| NATIONAL SPACE TECHNOLOGY LABORATOR | 37 | 2,430 | 37 | 2,951 | 37 | 2,860 |
| GODDARD SPACE FLIGHT CENTER | 452 | 14,574 | 479 | 16,397 | 500 | 18,076 |
| AMES RESEARCH CENTER | 278 | 11,221 | 291 | 12,368 | 307 | 13,708 |
| LANGLEY RESEARCH CENTER | 294 | 9,227 | 305 | 10,051 | 310 | 10,754 |
| LEWIS RESEARCH CENTER | 337 | 11,998 | 343 | 13,191 | 337 | 14,040 |
| HEADQUARTERS | 151 | 7,400 | 153 | 7,944 | 173 | 9,265 |
| TOTAL | 4,232 | 175,294 | 4,338 | 186,521 | 4,500 | 203,428 |

QUESTION A-13:

Please provide the following data for reimbursable employees:

a. the number and cost, by Center, of reimbursable employees, detailees, and post-graduate fellows
b. what amount is expected by Center, in FY 1987 and FY 1988, from other agencies and commercial customers to reimburse NASA for salaries of civil service employees
c. what other funds are provided, by agency, to cover other Research and Program Management costs

ANSWER A-13:

See Table H

TABLE H

## REIMBURSABLE DETAILEES

| | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|
| | Number | Salary Costs | Number | Salary Costs | Number | Salary Costs |
| JOHNSON SPACE FLIGHT CENTER | 71 | 3,953 | 71 | 5,031 | 71 | 5,660 |
| KENNEDY SPACE FLIGHT CENTER | 1 | 54 | 2 | 179 | 2 | 186 |
| AMES RESEARCH CENTER | 9 | 326 | 9 | 465 | 9 | 599 |
| LANGLEY RESEARCH CENTER | 1 | 77 | 1 | 79 | 1 | 81 |
| HEADQUARTERS | 18 | 676 | 18 | 700 | 18 | 700 |
| TOTAL | 100 | 5,086 | 101 | 6,454 | 101 | 7,226 |

## POST-GRADUATE FELLOWS

| | FY 1986 | | FY 1987 | |
|---|---|---|---|---|
| | Number | Salary Costs | Number | Salary Costs |
| JOHNSON SPACE FLIGHT CENTER | 13 | 585 | 14 | 644 |
| MARSHALL SPACE FLIGHT CENTER | 12 | 540 | 12 | 552 |
| NATIONAL SPACE TECHNOLOGY LABATORIES | 1 | 45 | 2 | 92 |
| GODDARD SPACE FLIGHT CENTER | 45 | 2,025 | 46 | 2,116 |
| AMES RESEARCH CENTER | 54 | 2,430 | 55 | 2,530 |
| LANGLEY RESEARCH CENTER | 17 | 765 | 16 | 736 |
| LEWIS RESEARCH CENTER | 15 | 675 | 15 | 690 |
| HEADQUARTERS | 0 | 0 | 1 | 46 |
| JET PROPULSION LABATORIES | 36 | 1,620 | 36 | 1,656 |
| TOTAL | 193 | 8,685 | 197 | 9,062 |

(13c)

NASA TOTAL

| FISCAL YEAR | FUND SOURCE | TOTAL | ARMY (91) | NAVY (92) | AIR FORCE(93) | OTHER DOD AGENCIES | SUB TOTAL DOD | COMMERCE (90,94) | ENERGY (9T) | OTHER FEDERAL (9X) | SUB TOTAL OTHER FEDERAL | NON-FEDERAL (8X) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY 1986 | 1 | 16,747 | 168 | 2,300 | 4,163 | 3,766 | 10,397 | 4,863 | 0 | 143 | 5,006 | 1,344 |
| | 2 | 6,404 | 1,034 | 368 | 2,192 | 759 | 4,353 | 793 | 239 | 361 | 1,393 | 658 |
| | 3 | 17,158 | 437 | 2,135 | 6,297 | 28 | 8,897 | 897 | 1,777 | 2,363 | 5,037 | 3,224 |
| | TOTAL | 40,309 | 1,639 | 4,803 | 12,652 | 4,553 | 23,647 | 6,553 | 2,016 | 2,867 | 11,436 | 5,226 |
| FY 1987 | 1 | 17,426 | 184 | 1,770 | 4,459 | 4,461 | 10,874 | 4,977 | 0 | 97 | 5,074 | 1,478 |
| | 2 | 6,168 | 1,213 | 387 | 1,627 | 939 | 4,166 | 316 | 212 | 310 | 838 | 1,164 |
| | 3 | 16,406 | 313 | 1,912 | 6,533 | 177 | 8,935 | 806 | 577 | 3,730 | 5,113 | 2,358 |
| | TOTAL | 40,000 | 1,710 | 4,069 | 12,619 | 5,577 | 23,975 | 6,099 | 789 | 4,137 | 11,025 | 5,000 |
| FY 1988 | 1 | 12,926 | 192 | 172 | 3,753 | 3,276 | 7,393 | 4,016 | 0 | 94 | 4,110 | 1,423 |
| | 2 | 6,249 | 1,274 | 326 | 1,751 | 1,068 | 4,419 | 68 | 190 | 382 | 640 | 1,190 |
| | 3 | 20,825 | 320 | 1,872 | 7,071 | 192 | 9,455 | 802 | 346 | 7,935 | 8,983 | 2,387 |
| | TOTAL | 40,000 | 1,786 | 2,370 | 12,575 | 4,536 | 21,267 | 4,886 | 536 | 8,311 | 13,733 | 5,000 |

NOTE: Fund Source 1 is Personnel and Related

Fund Source 2 is Travel

Fund Source 3 is Operation of Installation

13b.

| | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|
| | Number | Salary Costs | Number | Salary Costs | Number | Salary Costs |
| JOHNSON SPACE FLIGHT CENTER | 1 | 107 | 1 | 156 | 1 | 163 |
| KENNEDY SPACE FLIGHT CENTER | 43 | 2,350 | 72 | 3,949 | 12 | 1,640 |
| MARSHALL SPACE FLIGHT CENTER | 38 | 1,889 | 44 | 1,915 | 39 | 1,876 |
| NATIONAL SPACE TECHNOLOGY LABORATOR | 0 | 0 | 0 | 0 | 0 | 0 |
| GODDARD SPACE FLIGHT CENTER | 127 | 5,019 | 122 | 5,165 | 111 | 4,638 |
| AMES RESEARCH CENTER | 0 | 0 | 0 | 0 | 0 | 0 |
| LANGLEY RESEARCH CENTER | 22 | 925 | 22 | 925 | 22 | 925 |
| LEWIS RESEARCH CENTER | 50 | 2,130 | 33 | 1,487 | 0 | 0 |
| HEADQUARTERS | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 281 | 12,420 | 294 | 13,597 | 185 | 9,242 |

QUESTION 14a:

Please summarize the results of the latest round of SES bonuses.

ANSWER 14a:

o NASA's three percent Dollar Pool - $859,228

| Number of Awardees | | Salary | | Amount Distributed |
|---|---|---|---|---|
| 6 | at | 19% | = | $ 82,422 |
| 18 | at | 15% | = | 189,880 |
| 36 | at | 11% | = | 277,596 |
| 89 | at | 5% | = | 306,937 |
| | | | | $856,835 |

o Rank Awards

| | | | | |
|---|---|---|---|---|
| 14 | -- | -- | -- | $170,000 |

QUESTION 14b:

Please summarize the results of the most recent year under "merit pay".

ANSWER 14b:

NASA is covered by Public Law 98-615, which established the Performance Management and Recognition System (PMRS) to replace the "merit pay" system. In FY 1986, slightly less than the statutory maximum amount for PMRS performance awards, was 1.5 percent of estimated aggregate PMRS salaries. The dollar amount paid was approximately $2,505,000.

QUESTION 14c:

Please provide a current listing of re-hired annuitants.

ANSWER 14c:

(Please see attached listing.)

NASA currently has ten re-employed annuitants serving in full-time appointments:

| NAME | INSTAL. | GRADE |
|---|---|---|
| Henehan, Joseph E. | HQ | GM-15 |
| Williams, Walter C. | HQ | SES |
| Coy, Edward F. | HQ | Excepted |
| Driver, Elwood T. | HQ | SES |
| Kayten, Gerald G. | HQ | SES |
| Taylor, Charles A. | HQ | GS-15 |
| McMahon, Doris M. | ARC | GS-10 |
| Markey, Stanley | ARC | GS-12 |
| Nicholson, James R. | KSC | GS-14 |
| Fiorentino, Kelly A. | KSC | GS-12 |

Also NASA has one part-time re-employed annuitant:

| NAME | INSTAL. | GRADE |
|---|---|---|
| Edwards, Lawrence K. | HQ | Consultant |

An additional 49 re-employed annuitants, primarily experts, consultants or advisory committee member, are on NASA rolls under intermittent appointments and may serve on a daily basis when requested. These individuals serve without compensation (WOC) or are paid for the days when actually employed (WAE).

WITHOUT COMPENSATION (WOC) EMPLOYEES

| NAME | INSTAL. | GRADE |
|---|---|---|
| Comish, John W. | HQ | Consultant |
| Turner, Don N. | HQ | Consultant |
| Robinson, Lorne M. | HQ | Consultant |
| Kramer, James J. | HQ | Consultant |
| Hodge, John D. | HQ | Consultant |

WHEN ACTUALLY EMPLOYED (WAE) EMPLOYEES

| NAME | INSTAL. | GRADE |
|---|---|---|
| Lovelace, Alan M. | HQ | Consultant |
| Williamson, David Jr. | HQ | Consultant |
| Naugle, John E. | HQ | Consultant |
| Elms, James C. | HQ | Consultant |
| Sonnemann, Harry | HQ | Consultant |
| Gleason, James P. | HQ | Consultant |
| Carter, Charles H. | HQ | Consultant |
| Shapley, Willis H. | HQ | Consultant |
| Childs, Charles W. | HQ | Consultant |

| NAME | INSTAL. | GRADE |
|---|---|---|
| Shaw, James R. | HQ | Consultant |
| Krueger, Myron W. | HQ | Consultant |
| Zylstra, Donald L. | HQ | Consultant |
| Vincenti, Walter G. | HQ | Consultant |
| Lilly, William E. | HQ | Consultant |
| Pozinsky, Norman | HQ | Consultant |
| McLucas, John L. | HQ | Consultant |
| Townsend, John W., Jr. | HQ | Advis Comm Mbr. |
| Rediess, Herman A. | HQ | Consultant |
| Ludwig, George H. | HQ | Advis Comm Mbr. |
| Rabin, Herbert | HQ | Advis Comm Mbr. |
| Klein, Harold P. | HQ | Advis Comm Mbr. |
| Triffet, Terry | HQ | Advis Comm Mbr. |
| Mullin, Jerome P. | HQ | Consultant |
| Donlan, Charles J. | HQ | Consultant |
| Himmel, Seymour C. | HQ | Advis Comm Mbr. |
| Reeder, John P. | HQ | Consultant |
| Pilarinos, George | HQ | Expert |
| Houbolt, John C. | LaRC | GS-15 |
| O'Leary, William P. | GSFC | GS-13 |
| Taiani, Angelo J. | KSC | GS-12 |
| Yost, Ray E., Jr. | KSC | GS-12 |
| Davenport, Jansen R. | KSC | GS-12 |
| Bogart, William M. | KSC | GS-12 |
| McRoberts, Joseph J. | KSC | GS-12 |
| Senstad, Kenneth P. | KSC | GS-12 |
| Nick, D. Faye | KSC | GS-12 |
| Taylor, Annie E. | KSC | GS-12 |
| Underwood, William A. | KSC | GS-12 |
| Mizell, James F. | KSC | GS-12 |
| Gauger, Paul C. | KSC | GS-12 |
| Huddleston, Robert H. | KSC | GS-12 |
| O'Connor, Jerry J. | KSC | GS-12 |
| Whitaker, Philip F. | KSC | GS-12 |
| Dyke, Ray A. | KSC | GS-13 |

QUESTION A-15:

Please tabulate, by Center, the Research and Program Management funds used for repair and maintenance of facilities in FY 1987 and FY 1988.

| | FY 1987 | FY 1988 |
|---|---|---|
| Johnson Space Center | 11,163 | 13,715 |
| Kennedy Space Center | 9,316 | 10,407 |
| Marshall Space Flight Center | 5,190 | 5,619 |
| National Space Technology Laboratories | 579 | 671 |
| Goddard Space Flight Center | 6,089 | 7,024 |
| Ames Research Center | 3,209 | 3,359 |
| Langley Research Center | 887 | 829 |
| Lewis Research Center | 3,304 | 3,859 |
| Headquarters | 8,048 | 2,544 |
| TOTAL | 47,785 | 48,027 |

These funds are used for the repair and maintenance of facilities at NASA field centers and government-owned facilities. This includes the day-to-day maintenance and more substantial repair of utility systems, the interior and exterior of general purpose (office) and technical buildings and structures and pavement and drainage systems.

QUESTION 16:

Please summarize individually those quality assurance and safety related matters reported by NASA's Office of the Inspector General (OIG) to the Presidential Commission. How many investigations and/or audits have resulted from the Challenger accident: What is their current status? Please cite specifically.

ANSWER 16:

The following quality assurance and safety related matters were reported by NASA's OIG to the Presidential Commission on the Space Shuttle Challenger Accident (Commission).

March 24, 1986 — The Assistant Inspector General for Investigations advised a Commission staff member about an allegation received from a source of the Air Force Office of Special Investigations. The allegation appeared to concern a problem with bonding material on the external tank at Martin Marietta, Michoud Division. The allegation had surfaced during an OIG investigation. The Commission staff member was advised that the OIG had briefed the NASA Manager of the External Tank Office on the bonding problem and steps had been taken to correct the problem by ultimately returning to the original adhesive formula.

April 3, 1986 — An anonymous letter addressed to the Commission c/o the OIG was forwarded by the OIG to the Commission. The letter was from "A Kennedy Space Center Engineer" and expressed the writer's concern that the technical knowledge of the NASA management structure was deteriorating and that NASA needed a dual career development ladder to provide a kind of check and balance system in the organizational structure and to restore the technical excellence for which NASA was noted.

April 10, 1986 — A letter dated March 24, 1986, from the U.S. Department of Justice, enclosing a letter dated February 19, 1986, from an employee or a former employee of Martin Marietta, Denver, in which the writer stated that he discovered an error in a load cell used for testing titanium materials for use in the Space Shuttle.

May 28, 1986 — The Assistant Inspector General for Investigations met with two staff members of the Commission and displayed to them a memorandum of April 1, 1986, from the Director, SRM Project, Morton Thiokol, Inc., to the Commission, in which the Director commented on key issues and statements made during the Commission's proceedings of February 25 to 27, 1986. The Commission staff members informed the OIG that Chairman Rogers was briefed about the document and stated that the Commission did not need to have the document at that time.

The following five investigations resulted from the Challenger accident.

I-MA-86-096 — An anonymous letter was received by the OIG alleging that a NASA official had covered up the involvement of the Marshall Space Flight Center in the Shuttle incident, suppressed dissent within the Center, abused the Merit Promotion System, and used NASA aircraft for personal use.

The OIG investigation identified no misuse of the NASA aircraft. Additionally, no evidence was identified regarding any attempts to "cover up" MSFC's involvement in the 51-L accident.

Status: Closed.

I-MA-86-143 — This investigation was predicated upon a request by the Deputy Administrator regarding possible false statements made by a Marshall Space Flight Center employee, and possibly others, before the Commission. Specifics regarding the possible false statements were not provided.

A portion of the employee's testimony before the Commission was reviewed and additional transcripts of the employee's testimony were received by the OIG. The employee was interviewed by the OIG and stated that his testimony was complete and factual and that he had properly informed NASA management of the O-Ring problem well before the launch of 51-L. He also stated that there were video tapes of his Flight Readiness Review briefings regarding this subject which had been provided to everyone in the chain of authority, up to and including Level I. This employee has retired. A review of the employee's testimony and the video tapes is in progress to determine if any inconsistencies and/or changes of testimony exist.

Status: The OIG investigation is continuing.

I-AR-86-144 The Deputy Administrator expressed concerns to the Inspector General that unknown NASA officials may have pressured Morton Thiokol, Inc. (MT) to take reprisal actions against certain MT employees because of their testimony before the Commission.

OIG review of MT internal documents and distribution lists disclosed no organized effort or official policy to punish MT employees who opposed the launch of 51-L. OIG investigation established that NASA did not influence MT regarding the reassignments of one of the MT employees subsequent to the accident. A memorandum of rebuttal by one of the employees was not forwarded by MT to the Commission. Although it could not be determined whether MT intentionally withheld documents from the Commission, the Commission was in possession of substantive information from those documents. Commission staff advised that the availability of the documents in question did not affect its report. Facts of this case were presented to the U.S. Attorney's Office, Salt Lake City, UT, which advised that there was no violation of Federal law. A recommendation was made by the OIG to have NASA seek to amend the Federal Acquisition Regulations to include "whistleblower" protection for Government contractor employees.

Status: Closed.

I-MA-86-155 The Commission reported the possible unauthorized destruction of documents at the Marshall Space Flight Center. Two subject individuals allegedly had destroyed weekly management notes in violation of NASA's 51-L Document Impoundment Order. An initial investigation by the Commission determined that weekly notes had been destroyed; however, the destruction of the notes had no detrimental impact on the Commission's investigation.

The OIG investigation determined that no documents relative to the 51-L mission had been destroyed. Interviews disclosed that "it has always been policy" to dispose of the weekly notes once they have been submitted to the next higher level of management.

The Commission provided the OIG with an anonymous letter alleging that one of the subjects had held for over two months a memorandum containing key information regarding O-Rings and had failed to provide this information to the Commission. This allegation was not confirmed. The OIG recommended to MSFC management that the procedures for the weekly notes be included in a Marshall Management Instruction, and that future special orders from

NASA Headquarters be implemented immediately by supplemental MSFC directives. MSFC management responded that the need for weekly notes will be reviewed with the incoming MSFC Director. If it is determined that the notes are to be retained, procedures for submission and retention of the notes will be implemented. Additionally, MSFC will ensure that all future NASA Special Orders are circulated.

Status: Pending MSFC management final action.

I-MA-86-162 The OIG received allegations that a defective weld on the External Tank (ET) for the 51-L mission was not discovered during the inspection process, and that supervisors at Martin Marietta, Michoud Aerospace (MM/MA) were "covering up" defective welds on ET's.

The OIG learned that investigators from a Congressional committee advised MM/MA that they had secured sworn testimony that a supervisor had "covered up" a defective weld. OIG investigation disclosed that this incident was isolated and not indicative of any systemic problems at MM/MA. The supervisor who caused the incident did so in a moment of anger over a dispute involving some technical drawings. He has subsequently retired. Additionally, the OIG determined that as a result of the defective weld, which was undetected on the ET utilized in Mission 51-L, the X-ray reading procedures have been strengthened at MM/MA. According to the MSFC Chief Engineer's representative at MM/MA, this strengthening should significantly improve the X-ray reading process at MM/MA.

Status: Closed.

In response to the issues raised in the "Report to The President by The Presidential Commission On The Space Shuttle Challenger Accident," the OIG identified several potential audit areas, mostly in the Reliability and Quality Assurance function. As a result, the following audits are planned for initiation at the NASA centers in Fiscal Year 1987. Those audits annotated with an asterisk have been started. Based on available staff resources and other priorities, some of these audits may not be started until Fiscal Year 1988.

Goddard Space Flight Center

Quality Assurance

Johnson Space Center

* Contingency Planning for the Shuttle Carrier Aircraft (A-JS-87-002)

Kennedy Space Center

* Security Operations (A-KE-86-010)

* Administration and Management of Reliability and Quality Assurance Delegations (A-KE-87-001)

Manpower Requirements and Utilization

Quality Control on the Shuttle Processing Contract

Cannibalization of Shuttle Spare Parts

Cost Impact of Shuttle Delays

Lewis Research Center

Effectiveness of the Quality Assurance Function

Marshall Space Flight Center

Anomaly Reporting System (Martin Marietta/Michoud Assembly Facility)

QUESTION 17:

According to the latest report from the Office of Inspector General, there are currently 214 investigative cases pending. Please give a breakdown as to the length of time these cases have been pending, i.e. 3 months, 6 months, 1 year, 2 or more years.

ANSWER 17:

The breakdown of the 214 investigative cases pending as of September 30, 1986, is as follows:

| | |
|---|---|
| Under 3 months..... | 33 |
| 3 months..... | 38 |
| 6 months..... | 67 |
| 1 year..... | 49 |
| 2 or more years..... | 27 |
| TOTAL..... | 214 |

QUESTION 18:

Is there a system for follow-up work on pending cases in the Office of Inspector General? Please elaborate.

ANSWER 18:

Yes. The OIG has a system for follow-up work on pending cases in the OIG. At the time a new case is assigned, it is given a priority of either high, medium, or low. The Special Agent prepares an investigative plan for each case identified as high priority. All open cases are reviewed thoroughly by a supervisor at least once every 90 days. This review includes the priority status of the case.

The OIG has recently implemented an Activity Management System (AMS), which is an advanced computer system capable of many functions. A record of each investigation is created in the AMS when the case is opened and specific data is input during the life of the case. This computerized record enables OIG Headquarters to track the progress of an investigative case, to monitor the elapsed time on pending cases, and to determine the results of cases.

Responses to Written Questions Submitted by Chairman Nelson Resulting from the NASA Authorization Hearings on the FY 1988 Budget Request.

The Committee continues to be interested in your reimbursable programs.

QUESTION:

a. In the last six years, how many expendable launch vehicles (ELVs) and/or ELV launches have you managed or procured for the National Oceanic and Atmospheric Administration (NOAA)?

ANSWER:

a. NASA procured and launched eight (8) expendable launch vehicles for the National Oceanic and Atmospheric Administration (NOAA) as follows:

| Year | Atlas | Delta |
|---|---|---|
| 1981 | NOAA-C | GOES-E |
| 1982 | -- | -- |
| 1983 | NOAA-E/SAR | GOES-F |
| 1984 | NOAA-F/SAR | |
| 1985 | -- | -- |
| 1986 | NOAA-G | GOES-G (Launch Failed) |
| 1987 (THROUGH 3/31/87) | -- | GOES-H |

QUESTION:

b. Please describe the funding for these activities by year.

ANSWER:

b. The National Oceanic and Atmospheric Administration (NOAA) authorizes NASA, by a "Supply, Equipment or Services Order," to procure the Atlas and Delta launch vehicle hardware and launch services. Since it takes three years and sometimes longer to procure these vehicles, the NOAA provides incremental funding authority to NASA to initiate and complete the procurement and launch of each NOAA mission. Generally, at the outset, a financial plan is established outlining the funds required over a multi-fiscal year period for each mission's established launch date. This financial plan is revised at least once each year to verify and modify the funding requirements as may be necessary.

QUESTION A-19:

Please provide for the Committee the budget estimates for the recommended level of program activity for fiscal years 1989 and 1990 of a permanently manned Space Station.

ANSWER A-19:

The following funding is consistent with the request contained in the President's budget. These numbers are currently under review:

($ in millions)

| | FY 1988 | FY 1989 | FY 1990 |
|---|---|---|---|
| TOTAL | 767 | 1845 | 1995 |
| Development | 733 | 1800 | 1950 |
| Flight Telerobotic System | 22 | 45 | 45 |
| Operations Definition | 7 | -- | -- |
| Transition Definition | 5 | -- | -- |

In the case of the Atlas Launch Vehicle, NASA is committed to provide support for launching NOAA missions A through I beginning in 1979 and planned to be completed in 1991, at a current estimated cost of $110.0 million or $11.0 million average cost per mission. Through FY 1986, NASA has been authorized $98.2 million to conduct this program. The cost includes the modification of existing surplus Atlas launch vehicle hardware, originally procured by the DOD/ICBM program. Since the DOD is also using these surplus vehicles and a base support is established, only the modification cost is assigned to the NOAA missions. Currently, four of these vehicles remain to be launched.

In the case of the Delta Launch Vehicle, this vehicle is used to launch the GOES spacecraft into orbit for NOAA. The average Delta launch vehicle cost for GOES-D, -E, -F, -G, and -H missions is $26.4 million per vehicle. NASA has been authorized $132.3 million in support of these five launches. The cost assessed to NOAA includes hardware, mission uniques, launch services, NASA Civil Service salaries and travel.

QUESTION:

c. Were NASA personnel used to manage these activities? Were support contractors used? How many of each, for how long?

ANSWER:

c. NASA Civil Service personnel are used to direct and manage the NASA Expendable Launch Vehicle (ELV) program. This cadre of people manage and are dedicated to support the total ELV program of which NOAA missions are a part. A brief management description is provided for Delta and Atlas as follows:

DELTA - The Goddard Space Flight Center (GSFC) is the technical management center for the Delta ELV. The GSFC procures vehicle hardware, launch services and support in the conduct of providing launch transportation to NASA, other government (including NOAA GOES weather satellite missions), and domestic and international space mission users. To date, Delta has been launched successfully 168 times in 181 attempts. This program was initiated in 1959 and is the most used and most successful expendable launch vehicle in the NASA ELV family.

| Location | Delta ELV Civil Service Manpower | Contractor Support Manpower |
|---|---|---|
| GSFC | 27 | 2 |
| KSC | 35 | 25 |
| HDQTRS | 3 | -- |
| TOTAL | 65 | 27 |

The civil service staffing level reflects the current program support for the Delta Launch Vehicle. NASA is reimbursed for the civil service and contractor manpower applicable in support of NOAA missions.

ATLAS-E - NASA procures the Atlas-E launch services from the USAF. The Atlas-E is a surplus military missile refurbished and modified for space application. NASA Headquarters, Office of Space Flight provides vehicle program management and coordination for NASA and the NOAA in support of weather satellite launches from the Western Space and Missile Center in California.

| Location | NASA Atlas Program Civil Servants Manpower | Contractor Support Manpower |
|---|---|---|
| GSFC | 1 | -- |
| KSC/WTR | -- | 4 |
| HQTRS | 2 | -- |
| TOTAL | 3 | 4 |

QUESTION:

d. If NASA personnel were used to manage these activities, how were they supported? That is, in what account do their salaries appear?

ANSWER:

d. NASA is being reimbursed for NASA civil service costs expended in the management of NOAA launch vehicle transportation requirements in accordance with financial plans and schedules provided to NOAA.

QUESTION:

e. Will there be any impact on NASA if NOAA decides to procure commercial launch services?

ANSWER:

e. There will be an impact on NASA if NOAA decides to procure ELV launch services from commercial operators. Civil service staffing and contractor support will be reorganized and reassigned to other program areas as may be necessary to meet these changing conditions.

QUESTION:

f. Will NASA assist NOAA in such procurement?

ANSWER:

f. NASA has provided NOAA assistance in the "Request for Proposal" to U.S. Industry to supply space transportation service for NOAA/GOES-I, -J, and -K missions planned to begin launching in 1990. Future assistance for additional support to NOAA is under review and has not been finalized at this time.

QUESTION:

g. What will be or has been the role of NASA's Office of Commercial Programs in procurement of ELVs for NOAA by NASA?

ANSWER:

g. The NASA office responsible for the procurement of ELV's for other government agencies is the Office of Space Flight. Therefore, the Office of Commercial Programs would have no direct role if NASA were to procure an ELV for use by NOAA. However, the Office of Commercial Programs would continue serving as an advocate supporting the expansion of U.S. private sector investment and involvement in civil space activities. In this effort, the Office of Commercial Programs would negotiate and coordinate for access to NASA resources (facilities, services, technological expertise, and hardware) if access were requested by the commercial ELV operator.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: XC:MDD:brb:C-21358f

JUN 18 1987

Honorable Robert A. Roe
Chairman
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

ATTN: Subcommittee on Space Science and Applications

As a witness before the Subcommittee on Space Science and Applications on March 18, 1987, I have edited and am returning the hearing transcript forwarded to me for review. I am returning the transcript, and I request that the following information be included in the hearing record:

| Page(s) | Line(s) | Proposed Wording |
|---|---|---|
| 28 | 609-612 | We have devoted some attention to Expendable Launch Vehicles. We are also working various SRM&QA activities associated with the X-wing, propfan, high cost wind tunnels and things of this nature. |
| 59 | 1368-1369 | Well, we're targeting to get to our operating level at the end of Fiscal Year 1988. |

I understand that this letter may be inserted in the transcript in the form of an appendix and referred to by footnote in the main text.

Sincerely,

George A. Rodney
Associate Administrator for Safety,
Reliability, Maintainability
and Quality Assurance

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546

Reply to Attn of: C:MDD:C-21355f

MAY 7 1987

Honorable Robert A. Roe
Chairman
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Attention: Subcommittee on Space Science and Applications

Dear Mr. Chairman:

As a witness before the Subcommittee on Space Science and Applications on March 19, 1987, I have edited and am returning the hearing transcript forwarded to me for review. I am returning the transcript, and I request that the following information be included in the hearing record:

| Page | Line | Proposed Wording |
|---|---|---|
| 61 | 1448 | Currently NASA does not have any sites included on the National Priorities List. |

I understand that this letter may be inserted in the transcript in the form of an appendix and referred to by footnote in the main text.

Sincerely,

Billie J. McGarvey
Director, Facilities Engineering Division

I.D. LINE 76-600 (1208)